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E. J. STONE, M.A., F.R.S., President, in the Chair.

Lieut. William Heron Coombs, R.N., Indian Marine Survey;

Thomas Kilner Mellor, 3 Belmont Street, Huddersfield;

John Pender, M.P., 18 Arlington Street, W.; and

William John Vernon Vandenberg, F.M.S., Hornsey,
Middlesex;

were balloted for and duly elected Fellows of the Society.

Note on Delaunay's Expression for the Moon's Parallax.

By Professor J. C. Adams, M.A., F.R.S.

The process employed in Delaunay's Theory of the Moon consists in making a great number of successive changes from one system of elements to another, these changes being so conducted that the equations which give the variations of the elements always retain their canonical form, until at length all the sensible periodic terms in the disturbing function are got rid of, and the elements are thus reduced to three constants and three angles which vary in proportion to the time.

After each such change of elements, the expressions for the three coordinates of the Moon, which are supposed to be known in terms of the old system of elements, must be transformed so as to be expressed in terms of the new.

These transformations being made independently, we may, if we choose, find some of the coordinates with a greater degree of precision than others.

Delaunay has, as is well known, followed the example of Plana in developing his coefficients in series of ascending powers of the small quantities m , e , e' and γ .

Now, two of the Moon's coordinates, viz. the longitude and latitude, can be directly compared with observation, whereas

the third coordinate, viz. the radius vector, can only be indirectly inferred from observation through the parallax, to the sine of which it is inversely proportional.

Hence the accuracy of the theoretical values of the longitude and latitude can be much more severely tested by observation than that of the radius vector.

Delaunay has, on account of this circumstance, found the analytical expressions for the longitude and latitude with a much greater degree of accuracy than that for the reciprocal of the radius vector.

In the two former coordinates he has taken into account generally the terms of the 7th order, and in cases where the convergence of the series is found to be slow, he has included terms of the 8th and 9th orders. In the reciprocal of the radius vector, however, he has confined his attention to terms of the 5th order. Consequently, while the coefficients of the inequalities in longitude and latitude as found by him are generally only a small fraction of a second in error, the inequalities in the reciprocal of the radius vector are not found with sufficient precision to give even the parallax itself with all the accuracy which is desirable.

The coefficients of the inequalities of the parallax given by me in vol. xiii. of the *Monthly Notices*, p. 263, are considerably more accurate than those of Delaunay.

In the paper just referred to, I have given the coefficients to hundredths of a second only, and, as I have there stated, terms with coefficients less than $0''.05$ have been omitted except when they can be included in the same table with larger terms.

It may be worth while to give here a more complete view of the values of the coefficients of parallax which I obtained in 1853. These results are exhibited to thousandths of a second, as the calculation gave them, although the figures in the last place of decimals are not to be depended upon.

I add, for the sake of comparison, Delaunay's coefficients of the corresponding terms as given in the *Connaissance des Temps* for 1869, and also the coefficients of Hansen's theory as transformed by Professor Newcomb. The several arguments are expressed in Delaunay's notation.

Table of Comparative Values of the Coefficients of $\frac{\sin. \text{Parallax}}{\sin. 1''}$.

Arg.	Delaunay.	Adams.	Hansen transformed by Newcomb.
0	3422 ^{''} 7	3422 ^{''} 324	3422 ^{''} 09
<i>l'</i>	-0.4273	-0.400	-0.393
<i>l</i>	+186.5870	186.513	186.483
2 <i>l</i>	10.1984	10.170	10.161
3 <i>l</i>	0.6314	0.628	0.620

Arg.	Delaunay.	Adams.	Hansen transformed by Newcomb.
$4l$	"0414	"041	"040
$l-l'$	1'0523	1'157	1'144
$l+l'$	-0'9118	-0'948	-0'961
$2l-l'$	0'1030	0'123	0'149
$2l+l'$	-0'0917	-0'100	-0'122
$2F-l$	-0'7079	-0'710	-0'709
$2D$	28'1788	28'232	28'225
$2D-l'$	1'8764	1'915	1'920
$2D+l'$	-0'3276	-0'306	-0'301
$2D-2l'$	0'0760	0'089	0'092
$2D+l$	3'0636	3'090	3'084
$2D+l-l'$	0'1967	0'222	0'229
$2D+l+l'$	-0'0401	-0'047	-0'049
$2D-l$	34'1662	34'304	34'309
$2D-l-l'$	1'4523	1'449	1'447
$2D-l-2l'$	0'0454	0'050	0'049
$2D-l+l'$	-0'3789	-0'231	-0'227
$2D-2l$	0'2707	0'281	0'283
$2D-2l$	-0'2770	-0'307	-0'302
$2D-3l$	-0'1012	-0'116	-0'121
$2D-2F$	-0'1092	-0'106	-0'105
$2D-2F+l$	-0'0501	-0'048	-0'048
$2D-2F-l$	-0'0816	-0'086	-0'083
$4D$	0'1960	0'260	0'261
$4D-l$	0'4991	0'600	0'599
$4D-2l$	0'3104	0'372	0'372
$4D-l-l'$	0'0297	0'063	0'069
D	-0'9378	-0'949	-0'953
$D+l'$	0'1507	0'145	0'146
$D+l$	-0'0971	-0'106	-0'106
$3D$	0'0158	0'005	0'003
$3D-l$	-0'0199	-0'036	-0'037
$3D+l$	0'0025	0'002	
$D-l$	0'0076	0'014	+0'011
$2D-2l-l'$	-0'0127	-0'015	-0'019
$4D+l$	0'0185	0'032	0'043
$4D-2l-l'$	0'0159	0'030	0'032
$4D-l'$	0'0110	0'034	0'035

In the above many very small coefficients have been omitted.

As stated in my paper in the appendix to the *Nautical Almanac* for 1856, or in the *Monthly Notices*, vol. xiii. p. 177, my coefficients of parallax were obtained by comparing the results of the theories of Damoiseau, Plana, and Pontécoulant, and tracing out the origin of the discordances in the cases where those results did not agree with each other. These coefficients were also compared with those which I obtained by a transformation of Hansen's preliminary results as given in a paper in vol. xvii. of the *Astronomische Nachrichten*.

In Pontécoulant's method the expression for the reciprocal of the radius vector is first found, and then the expression for the longitude is derived from it. Hence the analytical values of the coefficients of parallax, given by Pontécoulant, vol. iv. pp. 149-152, 281, 282, 336, 337, are at least as accurate as the values of his coefficients of longitude.

In his final expression, however, in pp. 568-572, in which the several terms of the reciprocal of the radius vector are collected together, he neglects all terms of orders higher than the 5th, and the same omission takes place in the conversion of his coefficients of parallax into numbers.

Accordingly these numerical values, which are calculated in pp. 599-601, and collected together in p. 635, nearly coincide with the values of Delaunay, but are on the whole still less accurate.

It is greatly to be desired that some intrepid and competent calculator would undertake to make the numerous substitutions which would be required in order to find, by Delaunay's method, the expression for the reciprocal of the radius vector to the same order of accuracy as that which Delaunay has already attained in the case of the corresponding expressions for the longitude and latitude. The work would be one of simple substitution, not requiring the solution of any new equations, and consequently its only difficulty would consist in its great length.

The fact that Delaunay's determination of the value of the reciprocal of the radius vector is a comparatively rough one, affords a ready explanation of a difficulty which Sir George Airy has recently met with in his Numerical Lunar Theory.

The first operation required in this method is the substitution in the differential equations of motion of the numerical values of the Moon's coordinates as obtained in Delaunay's theory. If the theory were exact, the result of the substitution in each equation would be identically zero, so that the coefficient of each separate term in the result of the substitution would vanish. In consequence of errors in the coefficients obtained by Delaunay, however, this mutual destruction of terms will not take place, and the result of the substitution will consist of a number of terms the coefficients of which will depend on the errors of the assumed coefficients.

If, as is actually the case, these latter errors be so small that

their squares and products may be neglected, each of the residual coefficients may be represented by a linear function of the errors of the assumed coefficients, and the formation of the corresponding linear equations constitutes the second operation in Sir George Airy's method. The solution of these linear equations by successive approximations will finally give the corrections which must be applied to Delaunay's coefficients in order to satisfy the differential equations.

Now, since the proportionate errors of Delaunay's coefficients of parallax are considerable, and much greater than the errors affecting his coefficients of longitude and latitude, it will be readily understood that the result of the substitutions will be to leave considerable residual coefficients in the two equations which relate to motion parallel to the ecliptic, and much smaller residual coefficients in the third equation which relates to motion normal to the ecliptic, since in this last equation every error in the coefficients of the radius vector or of its reciprocal will be multiplied by the sine of the inclination of the Moon's orbit. This result, which might thus have been anticipated, is exactly what Sir George Airy has found to take place, according to a memorandum which he has recently addressed to the Board of Visitors of the Royal Observatory.

Since the errors affecting Delaunay's coefficients of parallax are comparatively large, it will be necessary to determine the factors by which these errors are multiplied in the equations of condition with a much greater degree of accuracy than is required in the case of the factors by which the errors of the coefficients of longitude and latitude are multiplied in the same equations. Otherwise, it will not be possible to deduce these last-mentioned errors from the equations with the requisite degree of precision. It will be necessary to take special precautions in order to determine with accuracy the corrections of the assumed coefficients in the inequalities of longitude which have long periods.

On the Change in the Adopted Length of the "Tabular Mean Solar Day," which takes place with every Change in the Adopted Value of the Sun's Mean Sidereal Motion. By E. J. Stone, M.A., F.R.S.

The view which I have taken that the so-called "mean solar day" of any of our tables is not necessarily the true "mean solar day," and that the "mean solar day" in use before 1864, for the calculation of our *Nautical Almanac*, is most certainly not the same interval of absolute time as that now adopted, and called a "mean solar day," is without doubt a startling assertion, and one likely to be sharply criticised; but I did not make it without a most careful consideration of the subject, and I feel perfectly certain of its truth. After all, the statement is not more startling than the facts for which it accounts. The meri-

dians of all our observations have either run away from the Sun and Moon in the last nineteen years by about 27^s , or astronomers have made a mistake in their count, as I have indicated, to this amount. Neither of these alternatives may appear probable, but the observations show that one of the alternatives must be accepted.

I consider that I have *mathematically* demonstrated my point, but my attention has been called to a letter by Sir G. B. Airy, in the *Observatory* magazine for May, in which that distinguished astronomer expresses, in very polite, but clear terms, his dissent from my views. The subject which I have opened out is of such importance, and the consequences which have already resulted from the changes made in 1864 are so serious in character, that I think it my duty to point out in the clearest possible manner the nature of the mistake made, and the fallacy of the reasoning by which Sir G. B. Airy has supported his dissent from my views.

In all scientific discussions the great difficulty is to fix the exact point at which our views diverge. When this can be done, the settlement of a mere mathematical question like the present should be comparatively easy. I feel, therefore, deeply indebted to Sir G. B. Airy for a clear statement of the evidence which he considers conclusive against the correctness of my views, and I shall be careful not to understate the force of the objections urged. I believe that the difficulty thus presented is the one which has chiefly influenced opinion against my views.

Sir G. B. Airy states that our observed Right Ascensions are referred to the adopted tabular places of our clock stars, and that no important changes in the tabular places of the clock stars were made with the change from Bessel's to Le Verrier's expressions for the sidereal time at mean noon in the *Nautical Almanac* of 1864. He points out that we determine the mean time corresponding to an observed Right Ascension of the Moon on the meridian from the formula that it is the equivalent in mean solar time of the sidereal interval (Observed R.A. — Tabular sidereal time at mean noon), and if we take from one of the Greenwich volumes an observed R.A. of the Moon—for instance, March 22, 1880, R.A. of centre = $9^h 10^m 59^s.02$ —and compute from this expression the Greenwich mean time, first with Bessel's value of the sidereal time at mean noon, and second with Le Verrier's value of the sidereal time at mean noon, the results will differ slightly, but by only the $\frac{1}{365}$ of the difference indicated by me. If, therefore, we compute from Hansen's tables the position of the Moon for these two separate times, the tabular R.A. will only differ by the $\frac{1}{365}$ part of the quantity indicated by me, and it is therefore quite impossible that the great errors at present existing between Hansen's tables and observations can be due to the use of the two different expressions for the tabular sidereal time. Now, I admit all the statements of fact made by Sir G. B. Airy, but I deny his conclusions. The method adopted for the computation

of Greenwich mean time is defective, and our count is wrong because our unit of time has been changed.

In questions of time there are two things to be taken into consideration—the count t , and the absolute length of the unit T , in terms of which the count is kept. If t_1 is the count with unit T_1 , and t_2 the count for the same interval of absolute time with unit T_2 , then we have

$$T_1 t_1 = T_2 t_2.$$

I have proved that the change from n' to $n' + \delta n'$ for the adopted value of the Sun's mean motion in the units of time T_1 and T_2 has established the relationship

$$T_2 = T_1 \left(1 + \frac{\delta n'}{n'} \right).$$

It follows therefore, that if the count, as now conducted, differs only slightly from that formerly adopted, or $t_2 = t_1$, the error made by this false reckoning is

$$T_2 t_2 - T_2 t_1 = -\text{time} \times \frac{\delta n'}{n'}.$$

This indicates that the error in our present reckoning in time is increasing at about the rate of 1^s.46 per annum. This correction, when introduced into our theories, accounts for the large discordances shown between theory and observation in the case of the Moon and also the Sun. But, of course, if Sir G. B. Airy's count is right, or t_1 does equal t_2 sensibly, then T_2 and T_1 cannot differ in the way indicated by me, and there must be *some* flaw in the reasoning, or some false assumption, in what I have given as a mathematical proof of the relationship

$$T_2 = T_1 \left(1 + \frac{\delta n'}{n'} \right).$$

I have stated the case against my views as strongly and clearly as possible.

It might be sufficient for me to ask those who refuse to accept my explanation of the cause of the existing errors in our theories, *which are proved to exist by our observations*, to distinctly point out my errors of assumption or of reasoning. But I am prepared to take the more direct course of showing that the present count is erroneous, and that when rightly conducted t_2 is not sensibly equal to t_1 .

The so-called mean time, which is directly computed from observation, is nothing more than the equivalent in mean solar time of the sidereal interval. Observed R.A. on meridian—tabular R.A. of meridian at mean noon, and it is the error made in computing this small interval on any particular day which Sir G. B. Airy considers the total error in count arising from the change from Bessel's to Le Verrier's expressions for the tabular R.A. of the meridian, and this interval, added to the count for “days”—

and here comes in the question of what "days" if the unit has been changed—is considered the Greenwich mean time deduced from observation. But an inspection of the form Observed R.A. on meridian—Tabular R.A. of meridian at mean noon, shows that the mean noon, in this way of calculating mean time, is the instant when Observed R.A. on meridian = Tabular R.A. of meridian at mean noon; and if we adopt two different expressions for Tabular R.A. of meridian at mean noon, we must have two distinct noons. The mean noon, according to Bessel's expression, comes earlier than the mean noon according to Le Verrier's expression on any particular day by the exact interval which Sir G. B. Airy supposes to be the total error which arises from the change from Bessel's expression to Le Verrier's; the accumulative effects of this error day by day in separating the tabular position of the meridian from the true position, are entirely neglected; and it is the neglect of this accumulation of errors in the count which has made Sir G. B. Airy's count wrong. Sir G. B. Airy has obtained nearly the same count in both cases because he has taken the count of so-called days in each case from the motion of the observed meridian with respect to the stars without considering that if the increase of R.A. in Bessel's day was 360° , it will no longer be 360° when a day of Le Verrier's scale is used, but a larger quantity than 360° in the proportion of

$$1 + \frac{\delta n'}{n'} : 1.$$

The following is a direct mathematical proof of the error made, but to avoid complexity I shall, at first, neglect any differences in the small terms multiplied by t^2 . The method of treatment, however, is perfectly general.

Let

$$S = C + (n + a \cos \omega_0 - u)t + \lambda t^2,$$

and

$$L = C + (n' + p)t + st^2$$

be the true tabular sidereal times for the meridian of Paris and the mean longitude of the Sun when $365.25 \times$ (the true physical mean solar day) is adopted as the unit of time. Then

$$n + a \cos \omega_0 - u - n' - p = 365.25 \times 2\pi,$$

$$\therefore (1+x)(n + a \cos \omega_0 - u - n' - p) = 365.25 \times 2\pi(1+x).$$

Let

$$(1+x)n = N; \quad (1+x)a = A; \quad (1+x)n' = N', \text{ etc., etc.}$$

$$\therefore N + A \cos \omega_0 - U - N' - P = 365.25 \times 2\pi(1+x).$$

Then

$$S = C + (N + A \cos \omega_0 - U) \frac{t}{1+x} + \lambda(1+x)^2 \left(\frac{t}{1+x} \right)^2$$

$$L = C + (N' + P) \frac{t}{1+x} + s(1+x)^2 \left(\frac{t}{1+x} \right)^2.$$

Let

$$t' = \frac{t}{1+x}.$$

$$S = C + (N + A \cos \omega_0 - U)t' + \lambda(1+x)^2.(t')^2$$

$$L = C + (N' + P)t' + s(1+x)^2.(t')^2$$

$$\therefore S - L = 365.25 \times 2\pi(1+x)t' + (\lambda - s)(1+x)^2.(t')^2$$

$$\therefore S = C + (N' + P)t' + 365.25 \times 2\pi(1+x)t' + \lambda(1+x)^2.(t')^2$$

Consequently, therefore, the sidereal time of the meridian can never assume the form

$$S = C + At + 365.25 \times 2\pi \cdot t + \lambda t^2,$$

unless the physical day is known and the true values of n' and p also known.

But let

$$S' = C + (n' + \delta n' + p)t + 365.25 \times 2\pi t + \lambda t^2$$

be the expression adopted by Le Verrier and now used in the *Nautical Almanac*, and suppose Bessel's value to have been the true value, I am really only concerned here with the change.

Then let

$$N' + P = n' + \delta n' + p,$$

which requires

$$(1+x)(n' + p) = n' + p + \delta n'$$

$$\text{or } x = \frac{\delta n'}{n' + p}.$$

Then

$$\text{true } S = C + (n' + \delta n' + p) \cdot t' + 365.25 \times 2\pi \left(1 + \frac{\delta n'}{n' + p}\right) t' + \lambda t'^2,$$

$$\text{tabular } S' = C + (n' + \delta n' + p)t + 365.25 \times 2\pi t + \lambda t^2.$$

It is absolutely necessary for the *true* computation of mean time by the formula adopted that the theoretical expression for the R.A. of the meridian should be identical with the true expression.

A comparison of these expressions shows that in order to make S' agree with S we must take

$$t = t' = \text{true } \frac{t}{1 + \frac{\delta n'}{n' + p}}$$

and introduce a term

$$365.25 \times 2\pi \frac{\delta n'}{n' + p} \cdot t'.$$

This term does not vanish at tabular mean noon, and *it is the neglect of this term* which makes Sir G. B. Airy's count wrong. This is a strict mathematical proof, which, without directly

assuming the change of unit, proves that it must practically have taken place with the adoption of the change from n' to $n' + \delta n'$ for the Sun's mean motion.

The error made has been that n' has been changed into $n' + \delta n'$ without recognising the necessity of the change of units, and the neglect therefore of the correction $365.25 \times 2\pi \frac{\delta n'}{n' + p} \cdot t$ to the tabular R.A. of mean noon when derived from Le Verrier's tables.

If we neglect this term we preserve nearly the same count, because that depends chiefly upon the term $2\pi \cdot t$, which is assumed the same in both Bessel and Le Verrier. The neglect of this quantity by preserving our count without preserving the same unit of time necessarily makes the absolute times all wrong. The error has been that the change of unit has not been recognised. No correction for the term $365.25 \times 2\pi \frac{\delta n'}{n'}$ has therefore been introduced into our count.

The following is the more general investigation. Since

$$(n + a \cos \omega_0 - u - n' - p) = 365.25 \times 2\pi$$

we have

$$(1 + x + y\tau)(n + a \cos \omega_0 - u - n' - p) = 365.25 \times 2\pi(1 + x + y\tau).$$

Let

$$n(1 + x + y\tau) = N; a(1 + x + y\tau) = A; u(1 + x + y\tau) = U;$$

$$n'(1 + x + y\tau) = N'; p(1 + x + y\tau) = P$$

$$N + A \cos \omega_0 - U - N' - P = 365.25 \times 2\pi(1 + x + y\tau),$$

since

$$S = C + (n + a \cos \omega_0 - u) \cdot t + \lambda t^2,$$

$$L = C + (n' + p)t + st^2$$

$$S = C + (N + A \cos \omega_0 - U) \frac{t}{1 + x + y\tau} + \lambda(1 + x + y\tau)^2 \left(\frac{t}{1 + x + y\tau} \right)^2$$

$$L = C + (N' + P) \frac{t}{1 + x + y\tau} + s(1 + x + y\tau)^2 \left(\frac{t}{1 + x + y\tau} \right)^2.$$

Let

$$t = \tau(1 + x + y\tau).$$

Then

$$S = C + (N + A \cos \omega_0 - U)\tau + \lambda(1 + x + y\tau)^2 \cdot \tau^2$$

$$L = C + (N' + P)\tau + s(1 + x + y\tau)^2 \cdot \tau^2;$$

$$\therefore S = C + (N' + P)\tau + 365.25 \times 2\pi\tau(1 + x + y\tau) + \lambda(1 + x + y\tau)^2 \cdot \tau^2.$$

Now consider a tabular expression

$$S' = C + (n' + \delta n' + p)t + 365.25 \times 2\pi \cdot t + (\lambda + \delta \lambda)t^2.$$

Let

$$(N' + P) + \lambda\tau = n' + \delta n' + p + (\lambda + \delta\lambda)\tau$$

be made an identity by a proper determination of x and y ; then since

$$N' + P = (n' + p)(1 + x + y\tau),$$

we have

$$x = \frac{\delta n'}{n' + p} \quad \text{and} \quad y = \frac{\delta\lambda}{n' + p};$$

$$\therefore S = C + (n' + \delta n' + p)\tau + 365 \cdot 25 \times 2\pi\tau \left(1 + \frac{\delta n' \cdot \tau + \delta\lambda \cdot \tau^2}{n' + p}\right) + (\lambda + \delta\lambda)\tau^2.$$

Comparing this with the tabular expression

$$S' = C + (n' + \delta n' + p)t + 365 \cdot 25 \times 2\pi \cdot t + (\lambda + \delta\lambda)t^2,$$

we see at once that S' can be made identical with S only by the following assumptions:—

- (1) The tabular t is really τ .
- (2) That we apply a correction

$$= 365 \cdot 25 \times 2\pi \left(\frac{\delta n' \cdot \tau + \delta\lambda \cdot \tau^2}{n' + p} \right).$$

The conclusions to be drawn are the same as before. The tabular sidereal times at mean noon require the correction

$$365 \cdot 25 \times 2\pi \left(\frac{\delta n' \cdot \tau + \delta\lambda \cdot \tau^2}{n' + p} \right)$$

where τ may be taken as sensibly equal to t . This demonstration proves the necessity for a correction which if neglected would produce an apparent secular acceleration of $4''$ in the Moon's mean motion.

The *rationale* of this method is simply that with every change in the unit of time we must, if we determine our count of days directly from the increase of Observed R.A. by 360° , introduce a correction to render this assumption true. If this is not done, we must of necessity make our theoretical Right Ascensions run away from our observed ones. There is no escape from such a false assumption.

Note on Mr. Stone's Paper in the last number of the "Monthly Notices."

The statement on page 343, line 8, and three following lines, is badly expressed. It should read: "From which it follows that the absolute time in an interval of t years expressed in terms of the unit t_1 exceeds the absolute time in an interval of t years expressed in terms of t_2 by

$$\frac{\delta n'}{n'} \cdot t."$$

Preliminary Account of a Telegraphic Determination of the Longitude of the Royal Observatory, Cape of Good Hope. By David Gill, LL.D., F.R.S., H.M. Astronomer at the Cape of Good Hope.

The longitude of the Royal Observatory, Cape of Good Hope, is the origin of longitudes for the British and American Transit of *Venus* Stations in South Africa and Madagascar. I have therefore thought it desirable to publish, as soon as possible, a brief account of the recent operations connecting the longitudes of Aden and the Cape, and to quote the approximate results obtained, in anticipation of the definitive results and more detailed account that will afterwards appear in the publications of the Observatory.

On Oct. 6, 1879, I addressed Sir George Airy, then Astronomer Royal, drawing his attention to the fact that about the end of the year the Cape would probably be in telegraphic communication with England, and asking whether advantage should not be taken of this circumstance to determine the longitude of the Cape of Good Hope as soon as possible. On Nov. 13 of the same year Sir George replied, "To mention the galvanic determination of the Cape of Good Hope Observatory is quite enough; the thing must be done as soon as may be."

After much correspondence and inquiry as to possibilities, I officially addressed the Secretary of the Admiralty on 1880, June 23, enclosing a general plan of the proposed operations, together with the necessary estimates of cost.

On 1880, Sept. 20, I took advantage of the kind invitation of Commodore (now Admiral) Sir F. Richards, K.C.B., to accompany him, as his guest, on board H.M.S. "Boadicea" to Port Elizabeth and Durban, partly to select sites of observation, but especially to ascertain whether signals could be exchanged directly between Aden and Durban without the intervention of an observer at Zanzibar. At Durban I made the necessary experiments, and found that signals sent from Aden, though quite useless for longitude purposes when received on the ordinary speaking galvanometers, were quite sharp and well marked when received on Thomson's air dead-beat* galvanometer. This fact I reported to the Admiralty by telegraph from Durban, and, on my return to the Cape, received official authority to proceed with the work. The necessary huts were soon made in Cape Town, but some unforeseen delays occurred in the despatch of the transit instruments and clocks from England, and it was not until 1881, March 2, that they reached the Cape.

* In the ordinary submarine galvanometer the mirror is suspended in water; in the air dead-beat the mirror is suspended in air. The mirror in the latter is nearly of the diameter of the cylinder in which it is hung, and the length of this cylinder is limited by glass plates. The mirror moves very freely at the first impulse, but the extension of the swing is checked by the passage of air round the edge of the mirror.

One of the transit instruments and a clock were mounted in a hut in the Observatory grounds without delay, and personal equation determinations were obtained on five nights. I was about to sail for Durban on March 18 when news was received of a breakdown of the land-lines from floods on the Transkei; difficulties also were presented by the discontinuation of the Mail Steamer Service between Durban and Delagoa Bay. I therefore postponed the commencement of actual operations for three months, and afterwards changed the original programme, relegating to Mr. Finlay, my chief assistant, the part of principal travelling observer; I had every confidence in his energy and skill, and my confidence has been amply justified by results. This modification of the original plan gave me more satisfactory control over the operation as a whole, and it enabled me at the same time to commence a series of heliometer researches on stellar parallax which must otherwise have been delayed for a year.

My general plan of operations was as follows:—The travelling observers were Mr. W. H. Finlay (F.), who successively occupied Durban, Aden, and the Cape; Mr. G. W. H. Maclear (M.), who observed first at the Cape, and afterwards at Durban; and Messrs. R. T. Pett (P.) and Isaac Freeman (I.), who remained at the Cape.

At the Cape (Observatory grounds), Durban, and Aden, there were erected three similar wooden huts, each containing a powerful portable transit instrument (3 inches aperture), a clock by Dent, and the necessary apparatus for sending and receiving signals.

The clock at Durban (the middle station) was regulated to mean time, the clocks at Aden and the Cape were regulated to sidereal time. At the Cape F. and M. observed exclusively with the 3-inch transit, P. and I. with the Transit Circle. The Observatory hut-clock and Observatory transit-clock were compared by coincident beats (through the intervention of mean time chronometers) by the observers before and after each time-determination.

Since Mr. Finlay observed both at Aden and the Cape, whilst Mr. Maclear remained at Durban, the sum of the longitudes Aden-Durban, and Durban-Cape Town, would be free from personal equation *if the personal equation of Finlay and Maclear remained constant during the operation, and if the personal equation of both observers was the same for land-line and for cable signals.*

But it would have been very unsafe to make any such assumption, for the operation was necessarily a very protracted one, the observers had long sea voyages intervening between the personal equation determinations and the actual observations, as well as great changes of climate and (as it proved) of bodily health. In fact, in such operations, the accidental error is a very small matter in comparison with the *possibility* of large systematic error due to change in the personal equation of the observers.

It was therefore essential to have some control on the constancy of the habit of observation of each of the travelling observers, and this I obtained by comparing the personal equation of F. and M. with that of $\frac{P.+I.}{2}$ both before and after the expedition.

That $\frac{P.+I.}{2}$ may be accepted as a tolerably uniform standard there was good *à priori* reason to believe. Both gentlemen were experienced observers, and had observed steadily and exclusively with the same instrument for the past eight years and twenty years respectively.

The following are the results of the different series of observations that have been made, under my direction, to determine their relative personal equation.

	No. of Stars.	P.-I. s
In 1879, Stars N.P.D. 75° to 105°	160	+0.178
„ „ „ 105° to 120°	206	+0.229
	Mean	+0.204
		Probable Error. s
1881, Apr. 9-June 27, Longitude Time Stars 10 nights		+0.229 $\pm$.009
Aug. 18-Sept. 19, „ „ 7 „	7	+0.207 $\pm$.009
Dec. 23-1882, Feb. 17 „ „ 8 „	8	+0.233 $\pm$.021

The remarkable constancy of these relative results may be accepted as proof of the probable constancy of the absolute personal equation of both observers.

From a discussion of the numerous observations for personal equation made before and after the expedition the following are the results obtained :

Before the Expedition.	After the Expedition.
F. +0.150	F. +0.110
M. +0.007	M. +0.047
P. +0.032	P. +0.034
I. -0.189	I. -0.191
$\frac{P.+I.}{2}$ -0.079	$\frac{P.+I.}{2}$ -0.079

where F. + M. + P. + I. = 0.

The personal equation of each observer both in sending and receiving land-line signals was also determined, by numerous trials, before and after the operation; these personalities resulted in quantities not exceeding 0.01, and are for the present neglected. The details will be given with a complete account of the operation.

To compare the personal equations of F. and M. in observing galvanometer signals, I arranged the following plan, which was

well carried out. I instructed F. to leave his clock at Aden, and to train a member of the telegraph staff there in the art of sending time signals. This duty was cordially undertaken by Mr. A. W. Prosser, of the telegraph staff there, and he acquired great skill in sending signals with uniformity and precision.

F. brought with him the Thomson dead-beat galvanometer which he had used at Aden, and mounted it in the hut at Durban, where the galvanometer used by M. was also mounted. Both galvanometers were then put in the Aden circuit, and signals sent by Mr. Prosser at Aden were observed by F. and M. at Durban, *each observer using his own galvanometer, but recording the same signal at the same place by the beats of the same clock.*

Any difference in the recorded times was therefore due either to personal equation or to a different degree of sensibility in the two galvanometers.

For longitude purposes it was not necessary to separate the observer's personality from the difference of the instruments, and therefore no observations were made with an exchange of galvanometers.

The following are the results of these experiments:—

Mean of 95 coincidences observed on 10 different days show that Finlay observed earlier than Maclear by 0^s.261.

And 1,820 differences (not coincidences) gave $0^{\text{s}}.263$.

The experiments were made with the galvanometer of F. alternately first and last on the line.

If we separate these cases we have

Finlay's galvanometer first on line, 47 coincidences =	0.267 ± 0.017	^s
Maclear's	0.255 ± 0.016	^s
	Mean	0.261

That is, the clock times of submarine signals observed by Maclear with the Durban galvanometer require the correction $-0^s.261$ to reduce to Finlay's habit of observation with the galvanometers employed by him at Aden.

There is still a final correction for personal equation of some importance; it is as follows:—

All the time-stars were purposely selected between Declination $+12^{\circ}$ and -29° , so as to lie between the zeniths of Aden and Durban. At the Cape, where the determinations of personal equation were made, the time-stars all move from right to left (i.e. from left to right in the field of the transit), but at Aden they move from left to right (i.e. from right to left in the field of the transit).

In 1879, in the course of some special investigations on personal equation, I found, for all the Observatory assistants without exception, that the personal equation, in observing a zenith star, systematically differs according as the feet of the observer

weather, which would have unduly prolonged the operation if this condition had invariably been insisted upon.

I have therefore accepted all the results in which there is a complete time determination at both ends within two or three hours of the exchange of signals; but no time determinations are accepted in which stars have not been observed in both positions of the transit.

The values of the levels were determined before and after the expedition.

All the observations have been made by *eye and ear* not only in the time determinations, but in sending and receiving signals. All signals have been given and observed by *coincidence*.

In order to obtain an additional control on the longitude of Durban, and thence on the personal equation of F. and M., I took advantage of a visit which Mr. Pett was about to make to Natal in July 1882. The Durban hut with its transit and clock were accordingly left *in situ*, in charge of the Government clerk of works.

Before and after his visit to Durban Mr. Pett determined his personal equation relative to Mr. Finlay, both observers using the three-inch Transits.

The results obtained were

	F.—P.
Before the departure of P.	+ 0'000
After the return of P. ...	+ 0'040
Mean	+ 0'020

After the application of all corrections for personal equation so derived, the following results were obtained:—

Cape Transit Circle West of Durban Hut.

Observers.	Date.	h m s
I. Finlay, at Durban Maclear at Cape	} June 1881	0 50 12'148 on 4 days. ± '025*
II. Finlay at Durban Pett and Freeman at Cape with Transit Circle	} June 1881	12'176 on 4 days. ± '018*
III. Maclear at Durban Pett and Freeman at Cape with Transit Circle	} Aug. & Sept. 1881	12'199 on 3 days. ± '022*
IV. Maclear at Durban Finlay at Cape	} Dec. 1881 & Jan. 1882	12'196 on 3 days. ± '017*

* These so-called "probable errors" are merely deduced in the usual way from the agreement of the separate results of each operation.

Observers.	Date.	h m s
V. Maclear at Durban	} Dec. 1881 & Jan. 1882	0 50 12'192 on 6 days. ± '030*
Freeman and Pett at Cape with Transit Circle		
VI. Pett at Durban	} July 1882	12'152 on 2 days. ± '004*
Finlay at Cape		
Both using 3 in. Transits		

In these six operations the personal equations have been applied as follows:—

I. and II.	$F. = \div 0'150$	= His equation as determined before leaving the Cape.
IV.	$F. = + 0'110$	= His equation as determined after his return.
I. and III.	$M. = + 0'007$	= " " before leaving.
IV. and V.	$M. = + 0'047$	= " " after his return.
VI.	$F. - P. = + 0'020$	= Mean of their relative equation as determined before and after Mr. Pett's visit to Durban.
II. III. and V.	$\frac{P. + I.}{2} = - 0'079$	= Constant.

To obtain the most probable value of the difference of longitude Durban—Cape, it will be perhaps best to give equal weight to the observations of the most strictly separate determinations, viz. :—

Cape (Transit Circle West) of Durban (Transit Hut).

		h m s
Finlay at Durban, I. and II.	=	0 50 12'162
Maclear " III. IV. and V. =		12'196
Pett " VI. =		12'152
Mean		0 50 12'170

It will now be convenient to give the separate results for the difference of longitude Aden—Durban. They are as follows:—

Durban, West of Aden (uncorrected).

VII.	Aug. 20	h m s
	23	48'59
	Sept. 2	48'43
	13	48'60
	18	48'32
	19	48'575
	22	48'45
	23	48'65
	26	48'53
	28	48'45
		0 55 48'531

* These so-called "probable errors" are merely deduced in the usual way from the agreement of the separate results of each operation.

We have besides these the following results of direct comparison with the Cape, Durban having no observations on these nights:—

Cape Transit Circle West of Aden.

VIII.	Aug. 26	$\begin{smallmatrix} h & m & s \\ 1 & 46 & 0\cdot69 \end{smallmatrix}$	Cape Observers, P. and I.
	27	0 ^s 53	" "
	Sept. 3	0 ^s 75	" P.

These results are without correction for personal equation.

In order to discuss the all-important question of the personal equation of Mr. Finlay at Aden, I adopt as definitive the above-found value of the longitude of the Cape west of Durban. Then for the mean of operations I. and II. we get for the seconds of the longitude in question $12^s\cdot162$, which would imply that at the time in question Finlay's adopted personal equation required the further correction $+0\cdot008$, that is

$$\text{In June 1881} \quad F. = +0\cdot158 \dots \dots (1)$$

From operation III. the seconds of the longitude are $12\cdot199$, which would imply that at the time in question Maclear's adopted equation required the correction $-0\cdot029$, that is—

$$\text{In Aug. and Sept. 1881} \quad M. = -0\cdot022 \dots (2)$$

The operations IV. and V., from their agreement with the result of operation III., appear to show the reality of the change of $+0\cdot040$ in Maclear's personal equation between September and December 1881, and that Maclear's personal equation for the latter period requires a correction of $-0\cdot024$, that is—

$$\text{In Dec. 1881, and Jan. 1882} \quad M. = +0\cdot023 \dots (3)$$

When Mr. Finlay returned to Durban from Aden he compared personal equation with Mr. Maclear on four nights with the result—

$$\text{In Nov. 1881} \quad F. - M. = +0\cdot208 \dots (4)$$

If we suppose Mr. Maclear's habit of observation to have changed gradually between September and December, we cannot be far wrong in adopting from (2) and (3)—

$$\text{In Nov. 1881} \quad M. = +0\cdot010, \text{ and hence from (4)}$$

$$,, \quad F. = +0\cdot198 \dots \dots (5)$$

We have from (1) and (5)—

$$\text{In June 1881} \quad F. = +0\cdot158$$

$$\text{Nov. } ,, \quad F. = +0\cdot198$$

And I adopt the mean of these as the most probable value of Mr. Finlay's personal equation at Aden in August and September.

We have, therefore, for the personal equation of F. and M. during the exchange with Aden—

$$\begin{array}{rcl} \text{In Aug. and Sept. 1881} & F. = +0^{\circ}178^s & \\ \text{,,} & M. = -0^{\circ}022 & \end{array} \left. \vphantom{\begin{array}{l} F. = +0^{\circ}178^s \\ M. = -0^{\circ}022 \end{array}} \right\} \dots \quad (6)$$

The results of operation VII. will therefore require the following corrections:—

	Corresponding Difference of Longitude.	Correction to Longitude.
Correction of $-0^{\circ}261$ to Maclear's time of recording submarine signals	...	$+0^{\circ}131$
Correction for Finlay's personal equation in determining time (6) ($+0^{\circ}178$)	...	$+0^{\circ}178$
Correction to same on account of reversal of direction of star's apparent movement in the northern hemisphere ($+0^{\circ}070$)	...	$+0^{\circ}070$
Correction for Maclear's personal equation in determining time ($-0^{\circ}022$)	...	$+0^{\circ}022$
		$+0^{\circ}401$
Uncorrected result of operation VII. ...	0 55 48.531	
Add Cape, West of Durban	0 50 12.170	
Hence Cape, West of Aden	1 46 1.102	

The three results of operation VIII. all require the first three corrections of No. VII. The results of August 26 and 27 require, besides, the correction

$$-\frac{P. - I.}{2} = +0^{\circ}079,$$

and the result of Sept. 3 requires the correction

$$-P. = -0^{\circ}033.$$

So corrected, the separate results become:—

Cape Transit Circle, West of Aden.

	h	m	s
Aug. 26	1	46	1.148
27			0.988
Sept. 3			1.096
Mean	1	46	1.077

It is almost needless to discuss the relative weight that should be given to these two closely accordant results, for it must

be remembered that the personal equation adopted for Maclear in operation VII. depends on exchanges with the Cape on only three nights.

Had Mr. Maclear's personal equation been supposed constant during his stay at Durban (which, in view of the probable errors of the separate determinations, is not an inadmissible supposition), and accepting $0^h 50^m 12^s \cdot 170$ for the definitive difference of the longitudes of Durban and the Cape, we should have as the personal equation of Maclear—

$$M. = +0^{\circ}008 \text{ during his stay at Durban,}$$

and this would make the personal equation of Finlay—

$$\begin{array}{lcl} \text{In Nov. 1881} & F. = +0^{\circ}200 & \\ \text{and as before in June } ,, & F. = +0^{\circ}158 & \end{array} \left. \begin{array}{l} s \\ \\ \end{array} \right\} \text{Mean } +0^{\circ}179$$

The former results of operations VII. and VIII. would then require the corrections $-0^{\circ}029$ and $+0^{\circ}001$ respectively, and would become:—

Cape Transit Circle, West of Aden.

				^h	^m	^s
By operation VII.	...	...		1	46	1'073
,, VIII.	...	...				1'078

It is obvious from these considerations that if we take the mean of the two solutions of operation VII. we adopt the mean of the almost equally probable hypotheses, and in consideration of the number of observations in operation VII., we may allow it double weight.

We have thus definitively—

				^h	^m	^s
From operation VII.	...	...		1	46	1'087 wt. 2
,, VIII.	...	...				1'078 wt. 1

whence—

$$\text{Cape Transit Circle, West of Aden} \quad 1 \ 46 \ 1'084$$

Economic considerations prohibited the exchange of observers at Aden, and therefore the chief uncertainty of the final result must be the personal equation of the observer at Aden. The results of Mr. Finlay's personal equation, determined at Aden two months before and two months after the Aden observations, differ only $0^{\circ}04$, and I think it extremely improbable that his true personal equation at Aden differed by this amount from the adopted mean.

The case will probably be met by assigning to the whole operation a probable error of $\pm 0^{\circ}03$. Beside such an error the accidental errors of the operation are comparatively insignificant—their rigid computation is therefore unnecessary.

disposal, but also for making all the necessary arrangements, and supplying all necessary aid. Also for the exact execution of this work to Mr. J. P. Edwards, his able and active assistant.

- (3) To H. Carlisle, Esq., and C. Stacey, Esq., the superintendents at Durban and Aden, not only for the efficient aid they rendered, but for their kindly hospitality to all engaged in the work.
- (4) To H. McEwen and A. W. Prosser, Esq., members of the telegraph staff at Durban and Aden respectively, for the active share which they took in the work, for the intelligent interest which they displayed, and for the great enhancement of its value which resulted from their labours of love.

Elliptic Elements of Comet b, 1882. By John Tatlock, Jun.

(Communicated by Prof. T. H. Safford.)

The present orbit is communicated as of possible interest, in comparison with the orbits of Dr. Kreutz and Prof. Frisby, with regard to the indications of the motion of the comet after it had passed perihelion. It was arranged for computation before Dr. Kreutz's elements, contained in No. 2482 of the *Astron. Nach.*, came to hand, as the copy of that number intended for this institution was lost in the "Cimbria." Had I seen his orbit sooner I should have made some changes in the dates of the places from which my orbit was computed. As it is, however, the date of my third place is 76 days later than the date of Dr. Kreutz's third place, and 66 days later than that of Prof. Frisby's. This fact will probably account for some of the discrepancies between the orbits of the above-named gentlemen and my own.

The elements are as follows, the computation being made by Gauss' method, as given in the *Theoria Motus*:—

Comet b, 1882.

T	=	Sept. 17.14302	
Log. q	=	7.9164079	
ω	=	70° 2' 23" 16	} Mean Equinox 1882.0
Ω	=	346 18 30.45	
i	=	142 3 28.22	
ϕ	=	89 20 18.35	
a	=	123.75	
e	=	.9999332	
P	=	1376.6 years.	

These elements result from the following normal places :—

Mean Equinox 1882'0.

G.M.T.	α				δ	No. of Obs.
	h	m	s	s		
1882, Oct. 8'0	10	29	22'76	$\pm 0'140$	$-10^{\circ} 15' 48''7 \pm 4''06$	21
Nov. 24'0	9	8	32'92	$\pm 0'237$	$-27^{\circ} 7' 29'' \pm 1'22$	16
1883, Jan. 29'0	6	13	34'56	$\pm 0'241$	$-22^{\circ} 54' 19''5 \pm 2'22$	16

The probable errors given above are only approximate, as the changes which took place in the nucleus and the different parts of the same used by different observers would preclude any definite determination of their values.

*Field Memorial Observatory of Williams College,
Williamstown, Mass., U.S.A.*

*Astrophysical Observations made during the Year 1882 at the
Herény Observatory, Hungary. By Eugen de Gothard.*

(Communicated by Dr. N. de Konkoly.)

Spectroscopic Observations.

In the year 1882 the spectra of 147 fixed stars and of two comets have been observed; the former with a small Zöllner ocular spectroscope, with one set of three prisms and a cylindrical lens; the latter with the same apparatus with a slit, the cylindrical lens being omitted.

On the appearance of the great September comet I endeavoured to perfect the instrument afterwards used for observing faint spectra. It consists of a Merz half-prism, movable by a fine micrometer screw; a bright line formed by a narrow slit in the focus of a small lens serves as an index. The table giving the motion of the micrometer screw in wave-lengths was constructed by a graphical method, from observations of nineteen known lines in the solar spectrum, made on November 6.

Out of the 147 stars mentioned above, the details are given only of 43 stars not included in Secchi's Catalogue.

Classification of Star-Spectra observed during the year 1882.

(Dr. Vogel's types.)

No.	Constellation.	Type I <i>a.</i>	Type II <i>a.</i>	Type III <i>a.</i>	Diff. and uncertain types.	Total
1	Cassiopeia	β, δ, ϵ	α		γ	5
2	Cepheus	α	γ		β	3
3	Perseus	β, δ	$\alpha, \gamma, \epsilon, \eta, \kappa?$	ρ	ζ, ν, τ, θ	12
4	Auriga	β, θ	α	π		4
5	Ursa major	β, ζ , Alcor. $\epsilon, \eta, \delta?$	α			8
6	Boötis	γ	δ			2
7	Corona bor.	α, β			θ	3
8	Hercules	$\delta, \epsilon, \iota, \nu, \rho, \sigma, \tau, \phi, \rho$	$\beta, \lambda, \pi, \xi?$	α	$\gamma, \zeta, \mu, \theta, \upsilon$	20
9	Lyra	$\alpha, \beta, \gamma, \zeta, \epsilon$, 16 Fl.		δ , 13 Fl.		8
10	Cygnus			Birm'ham		1
11	Andromeda	α, μ	γ, δ	β		5
12	Triangulum	β	α			2
13	Aries	β, γ , 14 Fl.	α	35 Fl.		5
14	Taurus	β, η , 17, 27 Fl.		α		5
15	Gemini	α, γ	β		δ	4
16	Canis. min.	α, β				2
17	Leo	$\alpha, \beta, \delta, \zeta, \sigma$	γ		η	7
18	Serpens	δ, ϵ, μ	α, η, θ			6
19	Ophiuchus	$\alpha, \gamma, \eta, \iota, \lambda, \nu$, 72 Fl.	$\beta, \epsilon, \kappa, \sigma$, 68 Fl.	δ	ζ, ρ , 70 Fl. Com. III. 6	17
20	Aquila	α, λ, θ	γ, η			5
21	Delphinus	ζ				1
22	Pegasus	α, θ	β, ϵ		γ (I. 6?)	5
23	Scorpius			α		1
24	Sagittarius	$\delta, \lambda, \mu, \pi, \rho, \sigma$	ξ		ζ	8
25	Scutum. Sob.		7 H. 3 H		6 H.	3
26	Capricornus	δ	β			2
27	Aquarius	γ	α, β			3
28	Pisces austr.	α				1
28		77	38	11	21	147

Number of observations, 169.

Number of days, 8.

March 15 and 16, June 17, July 15 and 24, August 7, and September 4 and 5.

Stars not in Secchi.

θ *Coronæ bor.*, mag. 4, bluish-white.

I endeavoured in vain to see some lines in the spectrum of this remarkable star.

ϕ *Herculis*, mag. 4, bluish-white.

H β , H γ , and D, very strong. I. a.

τ *Herculis*, mag. 3-4, bluish-white.

H β and H γ rather faint, but observed with certainty. I. a

σ *Herculis*, mag. 4, bluish-white.

The intensity of H β and H γ is characteristic. I. a.

π *Herculis*, mag. 3-4 yellow.

The spectrum very much resembles that of the Sun. II. a.

ϵ *Herculis*.

Spectrum faint, but H β and H γ distinctly visible. I. a.

ι *Herculis*, mag. 3-4, bluish-white.

H β and especially H γ very strong. I. a.

13 *Fl. Lyræ*, mag. 5-4, orange.

There are two bands both in the red and green part of the spectrum, and three in the blue. They are sharply defined towards the violet. III. a.

16 *Fl. Lyræ*, mag. 5, bluish-white.

Resembles the spectrum of γ *Lyræ*, but is fainter. I. a.

Birmingham red star, R.A. 20^h 36^m 38^s, D. + 47° 37' 6", mag. (var.) 8.

Colour intense red, the spectrum tolerably brilliant, with broad bands in the red, yellow, and blue. III. a.

35 *Fl. Arietis*, mag. 5, yellow.

The ultra-violet intersected by many bands. III. a.

14 *Fl. Arietis*, mag. 4-3, bluish-white.

I noted H β , H γ , and the faint D. I. a.

17 *Fl. Tauri*, mag. 6, bluish-white.

H β and H γ very well seen. I. a.

27 *Fl. Tauri*, mag. 4, bluish-white.

Identical with the spectrum of η *Tauri*. I. a.

δ *Serpentis*, mag. 3-4, white.

Hydrogen lines very strong. I. a.

η *Serpentis*, mag. 3, yellow.

Besides D and F there are other groups of lines. II. a.

θ *Serpentis*, mag. 4-3, yellow.

Identical with the former. II. a.

ζ *Ophiuchi*, mag. 3-2, bluish-white.

A very intense continuous spectrum, only D glimpsed occasionally. I. b.

- ι *Ophiuchi*, mag. 4-5, bluish-white.
Hβ and Hγ very distinctly visible. I. a.
- κ *Ophiuchi*, mag. 3-4, yellow.
Besides D and F, several other faint lines are visible. II. a.
- η *Ophiuchi*, mag. 2-3, bluish-white.
Hα, Hβ, and Hγ, distinctly seen. I. a.
- σ *Ophiuchi*, mag. 5, yellow.
D and F very distinct; other lines suspected in the green. II. a.
- β *Ophiuchi*, mag. 3, yellow.
Strongly resembles the solar spectrum; D, b, and G were distinctly noted. II. a.
- γ *Ophiuchi*, mag. 4-3, bluish-white.
Brilliant spectrum with strong Hβ and Hγ. I. a.
- ν *Ophiuchi*, mag. 4-3, white.
Characterised by very broad hydrogen lines. I. a.
- 68 *Fl. Ophiuchi*, mag. 4-5, white.
Though the spectrum is feeble, the characteristic hydrogen lines are distinctly visible. I. a.
- 72 *Fl. Ophiuchi*, mag. 3-4, bluish-white.
Intense spectrum with Hβ and Hγ. I. a.
Between 70 *Fl.* and ο *Ophiuchi* is a star of 7th mag., with a continuous spectrum of great intensity. The colour of the star is brick-red.
Latterly I could not find this star again, though I determined its situation and registered it in the atlas.
- λ *Aquilæ*, mag. 3-4, bluish-white.
Hβ and Hγ very intense. I. a.
- η *Aquilæ*, mag. var., yellow.
Its faint spectrum resembles that of the Sun. II. a.
- θ *Aquilæ*, mag. 3, bluish-white.
Faint spectrum, with intense F and a fainter Hγ. I. a.
- θ *Pegasi*, mag. 3-4, bluish-white.
The spectrum is characterised by broad Hβ, Hγ. I. a.
- μ *Sagittarii*, mag. 4, bluish-white.
Though the spectrum is very feeble, Hβ and Hγ are distinctly visible. I. a.
- δ *Sagittarii*, mag. 3-4, bluish-white.
Intense violet and dark hydrogen lines. I. a.
- λ *Sagittarii*, mag. 3, bluish-white.
Intense spectrum, with strong hydrogen lines. I. a.
- ξ *Sagittarii*, mag. 4, yellow.
Characterised by a dark D and intense F, and also by many faint lines in the green. II. a.
- ρ *Sagittarii*, mag. 4, white.
Resembles the spectrum of π *Sagittarii*, with strong Hβ and Hγ. I. a.

Observations of Comets.

Comets *Wells* and *Barnard* have been observed with but little success.

Measures have only been made of the spectrum of the great September comet. The result of all the observations is as follows:—

Date.	I.	Wave-length in mm. II.	III.	No. of Obs.	
Nov. 1	561.6	514.9	471.5	4	
3	561.5	514.5	470.7	5	
6	563.4	515.8	469.6	8	
7	562.6	516.0	470.9	10	
10	561.8	515.4	471.6	10	
11	560.9	515.3	471.7	10	
12	562.0	515.4	470.9	10	
18	561.4	515.4	471.3	5	
Mean	...	561.9	515.3	471.0	62

Comparing these results with those obtained by Dr. de Konkoly ("On the Chemical Constitution of Comets," Royal Hungarian Academy) we obtain the following differences:—

Results of my observations	...	...	561.9	515.3	471.0
Mean of all De Konkoly's observations			560.9	515.6	469.5
Difference	...	...	+ 1.0	- 0.3	+ 1.5

The intensities of the bands were estimated at 0.2, 1.0, 0.5, on November 1.

Observation of the Solar Eclipse 1882, May 16.

First contact	...	...	h m s	
			19 0 12.2	Eugen de Gothard
			19 1 1.5	Alexander de Gothard
Last contact	...	...	20 47 56.2	Mean 20 ^h 47 ^m 58.5 H.M.T.
			48 0 8	

Alexander de Gothard observed the first contact a little too late. Instruments: the 10 $\frac{1}{4}$ -inch Browning Reflector, with a reduced aperture of 6 inches, and an achromatic telescope by Bardon et Fils, of Paris.

During the eclipse six successful photographs were obtained.

[These photographs are deposited in the Society's Library.]

Physical Observations of Jupiter and Mars made during the Year 1882 at the Astrophysical Observatory, Herény, Hungary. By Alexander de Gothard.

(Communicated by Dr. N. de Konkoly.)

The total number of observations of *Jupiter* made this year was 36; 29 belong to the opposition of 1881-82, and seven to the beginning of the opposition of 1882-83.

A great difference is at once perceived between the drawings made in spring and autumn; and this difference is based on real changes.*

The typical distribution of the bands was always the same in the first half of the year. There were visible three chief bands—an equatorial, a southern, and a northern one. For the second half of the year such uniform distribution no longer prevailed. The colour of the equatorial band had on every occasion a certain characteristic rusty-red tone, with very variable shadings.

The form of this band is also changing, but its division and fringing are almost exclusively confined to its southern border.

The colour of the southern band is a faint grey; most of it consists of ashy branches, forming small stripes and prominences, appearing only on its equatorial side; therefore the zone between these two bands shows the most detail and variety. Under the red spot this southern band always appears narrower or curved.

The form and colour of the northern band are very constant; the colour is generally a drab of a feeble greenish tone. The poles of the planet are covered sometimes with a grey nebulous veil of variable extent, the boundary of which is sometimes sharp and sometimes faint.

The red spot is sometimes surrounded by a brilliant white zone. It is almost constantly accompanied by a dark grey cloudy line, narrowing towards the equator to a triangular figure, thus forming the boundary of the above-mentioned bright zone.

On most occasions I observed that the form of the red spot was elliptical; sometimes it is bounded by lines parallel with the major axis, the ends of which are united by half circles.

The colour of the red spot varies very much; sometimes it appears of a dirty flesh colour, at others of a feeble red tint. In the autumn observations it was not visible, so that I began to think it had disappeared. In the spring of 1883 I saw it again, though of an exceedingly pale colour; it was therefore only the unfavourable atmospheric conditions that caused its invisibility. Nevertheless I conclude that the phenomenon is disappearing; and I think there is little hope of finding it again in the opposition of 1884.

* The drawings of *Jupiter* and *Mars* are exhibited in the Society's Library.

In general but little can be said about the observations of the second half of the year; the surface of the planet shows so great a variability that no resemblance can be found between the drawings. But it was remarked that the equator was always covered with a greenish-yellow zone, extending from one-fourth to one-third of the minor axis of the disk, and filled with irregular clouds and nebulosities. The poles were always surrounded by a dark shade.

The instrument with which the observations have been made is the $10\frac{1}{4}$ -inch Browning-Newtonian Reflector.

The description of the drawings of *Mars* is much more difficult than of *Jupiter*, as well-defined spots can only be seen with good definition. Thus but little remains to say of the observations.

In January and February of the year 1882 nine observations and drawings were made. Some of the drawings show well-defined spots of great extent.

The colour of the markings is more decided towards the centre of the disk. Here the greyish-green markings contrast very strongly with the red portions of the disk, and thus appear well defined.

Towards the limb the colours are paler and feebler, no part being at all defined.

The northern ice-cap was distinctly visible on all occasions, surrounded by a ring of bright white colour.

Eugen de Gothard believed that he twice glimpsed one of the satellites: viz. on February 5, 8^h 0^m H.M.T., when he saw an exceedingly small starlike point at a distance of about 2.5–3 *Mars*-diameters from the disk in the N.W. direction; and on February 9, 8^h 15^m H.M.T., when a bright point was noticed on the S.E. side of the planet at about the same distance. The magnifying power was 436.

Note on the Chromosphere. By the Rev. S. J. Perry, F.R.S.

A letter appeared in the *Observatory* a few months since containing a communication from Professor Respighi on the subject of the Chromospheric Lines between A and C, and a wish was expressed that English observations bearing on his results might be brought before the public. I have therefore thought it worth while to bring under the notice of the Fellows of the Society an observation taken a few days ago.

On May 30, whilst taking the usual daily measures of the Chromosphere, my assistant at Stonyhurst Observatory, Mr. W. McKeon, observed the bright line Kirchhoff 654.3 between C and B. It was only visible near the point $63^{\circ} 58'$ E. of N., image direct. Sweeping round the Sun's limb the chromosphere became suddenly intensely bright at this point, and also very wide, and an

extraordinary bright cloud, displaced towards the less refrangible portion of the spectrum, appeared near the upper end of the C line. The line K 654'3 was almost as bright as C, but was not displaced. This brilliant portion of the chromosphere proved to be the beginning of a large prominence, and as the prominence increased in height the line K 654'3 faded away, becoming invisible where the prominence was highest and brightest. On sweeping back to the former position the bright cloud was found to have disappeared, and both C and K 654'3 were somewhat less brilliant than before.

The solar drawing on June 2 shows that a moderately large group of spots was just on the limb at the point where K 654'3 was seen on May 30. Another larger group of spots has burst out since May 30, and is already past the centre of the disk.

Stonyhurst Observatory :
1883, June 5.

Note with respect to the Limb of the Planet Jupiter.
By A. C. Ranyard, M.A.

At a recent meeting of the Astronomical Society Capt. Noble stated that, in observing an eclipse of *Jupiter's* fourth satellite on April 4, 1883, he was struck with the slow manner in which the light of the satellite disappeared and flashed up again at intervals, so brightly that he could not persuade himself that the changes of light were due to scintillation or disturbance in the Earth's atmosphere. Mr. Marth showed that the slow disappearance was due to the fact that the satellite, on the occasion referred to, entered the northern edge of the cone of shadow cast by the planet very obliquely; but the flashing up again of the light of the satellite at intervals was not explained. Direct observations of *Jupiter* point to the existence of an extensive atmosphere in which great masses of cloud are suspended, I would suggest that the flashing up at intervals of the light of the satellite was due to its passage through darker regions in the penumbra of the planet's shadow caused by clouds in the atmosphere of *Jupiter*. The oblique passage of the satellite through the penumbral region of the shadow, probably causing the changes of illumination to last for a longer period than on ordinary occasions, when the satellite plunges more perpendicularly into the cone of shadow.

The object of the present note is to bring together some observations of eclipses of *Jupiter's* satellites and occultations by the limb of the planet, which tend to show that *Jupiter* has not a definite, hard outline, but that the limb is partially transparent with here and there regions of greater opacity.

Dr. T. D. Siminton, of St. Paul, U.S.A., observed the previous eclipse of the fourth satellite. On that occasion the

satellite only just grazed the northern edge of the shadow cone. An account of the observation is given in the *Sidereal Messenger* for April 1883. Dr. Siminton says: "The light of the satellite rapidly decreased till $10^h 55^m$, when, if visible at all, the light of the body was excessively faint. This continued but a minute or two, when I was sure of it again by glimpses, and in a minute or two more, before $11^h 0^m$, I could see it steadily." The observation was made with a 3-inch achromatic.

On April 26, 1863, Mr. S. Gorton observed an occultation of the second satellite. An account of the observation is given in the *Monthly Notices*, xxiii. p. 217. He says "the occultation occupied nearly seven minutes, during which time, owing apparently to the movement of the atmosphere, the satellite seemed to disappear and appear again several times."

On October 5, 1878, Mr. Todd, the Director of the Adelaide Observatory in South Australia, observed an eclipse of the fourth satellite. An account of the observation is given in the *Monthly Notices*, xl. p. 175. He says in a note with respect to the time of disappearance: "Time considered exact, but lost sight of satellite several times before final disappearance; planet not well defined; Moon a little to east of planet."

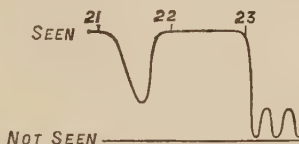
On Sept. 14, 1879, Mr. J. Turner observed an occultation of 64 *Aquarii* with the great Melbourne Reflector and a power of 350. An account of the observation is given in the *Monthly Notices*, xl. p. 141. He says: "At the moment of contact the star did not instantly disappear, but seemed to possess a visible disk, the limb of *Jupiter* seeming to advance gradually upon it, the star, by-and-by, appearing to be bisected and then gradually disappearing altogether. The time of final disappearance was $10^h 7^m 47^s.6$ M.M.T., at which instant the circle of *Jupiter's* limb appeared perfect; previous to this the star appeared as a small protuberance upon the limb, which *gradually* got smaller until final disappearance. The time of first contact was not noted, but I estimated the interval between contact and disappearance at about 35 seconds; certainly not less, it might be more. For about 10 seconds after disappearance the star could be seen *through Jupiter's* atmosphere as a speck of light seen through ground glass. This also disappeared *gradually*. There was no fitful disappearance and reappearance, but gradual disappearance throughout. . . . At $12^h 34^m 47^s$ I could clearly see a minute protuberance where the star was expected to appear. This protuberance exactly resembled the one-half of the disk-like appearance of the star at disappearance [the planet was then hidden by clouds and] at $12^h 37^m 57^s$ I got another clear view for about 10 seconds, when the star was seen well separated from *Jupiter*. The small protuberance noted three minutes previously was thus proved to be the reappearance of the star."

The same occultation was observed by Mr. Ellery with an 8-inch achromatic, power 300. He says: "The star first appeared to touch the planet's limb at $10^h 5^m 19^s$ M.M.T., and was

visible in that position for nearly two minutes, when, while still making a projection on the planet's outline, it all at once appeared as if seen through a mist or haze, and *entirely projected on the planet's limb*. This faded away in about ten seconds, leaving still a decided nipple-like projection on the edge of the planet, as if the planet itself bulged out, without any signs of the true light of the star; and at $10^h 7^m 43^s.8$ this disappeared, leaving a clean outline to the disk."

Mr. E. J. White, of the Melbourne Observatory, who observed the occultation with a $4\frac{1}{2}$ -inch achromatic, says that "Although the definition was very good in a cloudless sky, yet slight oscillations of the planet occurred which made the star momentarily disappear. At $10^h 6^m 23^s.7$ M.M.T. I thought the star had really disappeared; but on looking again I saw it projected on *Jupiter* as a bright nipple, which seemed to gradually lessen in size till $10^h 7^m 40^s.4$, when I finally lost sight of it."

Professor E. C. Pickering has kindly communicated to me the following note with reference to an occultation of a 7.3 magnitude star which he observed on April 14, 1883. The star occulted was D. M. + $23^\circ 1087$.



The diagram, which is made from a sketch given by Prof. Pickering, represents the variation in the intensity of the light of the star during the two and a quarter minutes before its final disappearance. His notes with respect to the observation run as follows:—

G.M.T.			G.M.T.		
h	m	s	h	m	s
14	21	17	14	23	1
	30	Seen.	13		Not seen.
	30	Seen with difficulty.	13		Suspected.
	44	Suspected.	24		"
	48	Seen.	34		Not seen.

"For about two minutes before final disappearance the star alternately disappeared and reappeared without obvious cause; seeing pretty good and uniform throughout. For twenty-six minutes the planet was carefully watched, and the star was again seen at $14^h 49^m 56^s$. The uncertainty in this time must have been very small, as the observer had not removed his eye from the telescope for some time previously. The star continued visible without the fluctuations noticed at disappearance. The occultation occurred near the northern limb of *Jupiter*. E. C. Pickering (observer), A. Searle (recorder)."

The observation was made with the 15-inch achromatic of Harvard College Observatory.

On April 14, 1883, *Jupiter* moved through a little less than $11''$ of arc in twenty-six minutes of time, its motion amongst the stars being nearly parallel to the planet's equator, but slightly northward. In the two minutes and a half, the time which elapsed between the first change in the intensity of the light of the star and its final disappearance, the limb of the planet moved through about $1''\cdot08$. Taking *Jupiter's* distance from the Earth on April 14 as 507,610,000 miles, an arc of $1''\cdot08$ would correspond to a motion of the planet's limb through 2,600 miles. Assuming *Jupiter's* equatorial semi-diameter at the date of the observation to be $16''\cdot6$, and its polar semi-diameter to be $15''\cdot6$, the rays from the star passed through the planet's atmosphere at the time when the first change of intensity was observed, at a height of 890 miles above the level at which the rays were last transmitted just before the light of the star was extinguished.

If *Jupiter* had no atmosphere, and its limb were opaque, the region of total shadow cast by the planet would lie within an elliptical *conocuneus*, with its base upon the planet and its apex line at a distance of nearly seventy millions of miles beyond *Jupiter*; at the distance of the fourth satellite (1,192,000 miles) the elliptic section of the total shadow would be surrounded by a zone of penumbral shadow about 2,080 miles wide. The satellite itself has a diameter of 2,900 miles.

A refracting atmosphere about the planet would, by curving the Sun's rays inwards, tend to diminish the area of total shadow; but the time occupied by the satellites in traversing the shadow cone shows that the horizontal refraction of the Jovian atmosphere cannot be great at the height at which the Sun's light is extinguished in passing through the limb of the planet. There will always be some uncertainty as to the observed diameter of the shadow cone, for the satellites probably disappear before the Sun's disk is wholly eclipsed on the last portion of the disk of the satellite which enters the shadow. Observations of eclipses of our own Moon show that the Earth's shadow appears larger than the geometrical shadow which would be cast by a body as large as the Earth not surrounded by an atmosphere. Mädler estimated this increase of diameter as $\frac{1}{51}$ th* (see *Astr. Nach.* xv. p. 29), and we know that clouds in our own atmosphere seldom, if ever, float at a height of ten miles above the sea level.

The Sun's disk at the distance of *Jupiter* has a diameter of less than $6'$; and when the fourth satellite passes centrally through the shadow cone, any point on the satellite occupies about six and a half minutes in traversing the penumbral region.

* Mr. Godward informs me that the *Nautical Almanac* uses the fraction $\frac{1}{60}$ as representing the increase in the diameter of the observed shadow over the geometrical shadow thrown by the Earth. In the case of *Jupiter's* satellites, the predictions of eclipses are given as calculated for the geometrical shadow.

The satellite traverses its own diameter of 2,900 miles in about nine and a half minutes.

Taking into account the degradation of brightness towards the Sun's limb, we can hardly suppose that the Sun's light would be diminished so that the satellite would be lost sight of while a section of the Sun's disk with a versine of $1'.5$ remained visible at a point half-way between the centre of the satellite and the following limb—that is to say, four minutes before the geometrical eclipse of the last portion of the Sun's disk at the following limb of the satellite. But even with the tables at present in use the predicted times for central eclipses of the fourth satellite do not differ from the observed times by as much as four minutes. We may consequently be sure that the horizontal refraction in the atmosphere of *Jupiter* at the height where the last ray is transmitted does not amount to $4'$ of arc.

I would suggest that the spectrum of the light of the satellites should be examined as they disappear in the shadow of the planet, to see whether any evidence of absorption can be detected due to the long passage of the illuminating rays through the atmosphere of *Jupiter*.

Observations of U Monocerotis and LL 14551, with a new Photometer. By the Rev. T. E. Espin, B.A.

The following observations of *U Monocerotis* were made with a photometer and opera-glass. The photometer was attached to the 5-inch Refractor, and is of simple construction; a beam of light is cut off by a circular stop, and leaves a disk of light on a dark field. The beam of light is totally reflected by a prism to the eyepiece end from a small oil lamp, that can be turned up or down at pleasure. So long as the eyepiece is in focus the star will be seen on the bright and dark background alike; but by gradually drawing out the tube, the image of the star becomes a disk, which up to a certain point will be seen on the bright part of the field; but when the eye-piece is drawn out beyond that point, it will be invisible, being lost in the brightness. Obviously the brighter the star the further the tube must be drawn out to reach the point of disappearance. The method employed in determining the magnitude of a variable star is to measure one star whose magnitude is known, and is greater than the variable, and one whose magnitude is known and less than the variable.

The distance the tube is drawn out is read off by a scale from a mark on the telescope to some mark on the draw tube. The variable star is then measured. The magnitudes of the two comparison stars being known, the difference of readings will equal the difference of magnitudes, and it becomes a matter of simple proportion to find the magnitude of the variable star. The variable star *U Monoc.* was discovered by Dr. Gould, of

Cordoba. The place in the *Uranometria Argentina* is (1875) R.A. $7^{\text{h}} 24^{\text{m}} 50^{\text{s}}$, Dec. $-9^{\circ} 31' 0''$, and the period there is given as about 46 days. As far as I am aware there are no other published observations save those of the Cordoba Observatory. Though only two stars are necessary as comparison stars, four other stars have been measured occasionally to test the photometer, and do away with any errors arising from variation in the comparison stars.

The following are the places from the *Uranometria Argentina*:—

	R.A.	Decl.	Mag. Ur. Ar.	Mag. Photom.
	1875. h m s	1875. ° ' "		
(1) 5 Puppis	7 42 6	$-11^{\circ} 53' 2''$	5.9	6.0 (assumed)
(2) LL 15283	7 44 10	$-8^{\circ} 52' 2''$	6.2	6.19
(3) LL 14706	7 26 6	$-8^{\circ} 36' 7''$	6.3	6.44
(4) LL 14599	7 23 26	$-10^{\circ} 4' 2''$	6.2	6.52
(5) W.B. 664	7 22 38	$-9^{\circ} 47' 4''$	7.0	7.0 (assumed)
(6) LL 14551	7 21 59	$-11^{\circ} 18' 3''$	6.3	var. 6.09 + 6.77

Of these stars, No. 2 was measured on five nights; the difference between the extremes being 0.27. No. 3 was measured on eight nights; the difference between the extremes being 0.10. No. 4, a suspected variable, was measured on fourteen nights; the difference between extremes being 0.24. While No. 6 was measured on twenty-one nights, and estimated on five others. This star is undoubtedly variable between 6.09 and 6.77. The following are all the determinations of magnitude I have obtained:—

LL 14551, R.A. $7^{\text{h}} 21^{\text{m}} 59^{\text{s}}$, Dec. $11^{\circ} 18' 3''$ S. (1875).

	d	h	Mag.	
1883, Feb.	14		6.30	Measured
	15		6.20	"
	23		6.19	6.09 Double set of measures.
Mar.	1		6.26	Measured.
	3		6.31	"
	11		6.0	Estimated; clouds troublesome.
	12		6.51	Measured.
	13		6.67	"
	14			Brighter.
	15		6.53	Measured.
	17	9	6.35	"
	18	$8\frac{1}{2}$	6.42	"

	d	h	Mag.	
1883, Mar.	23	9 $\frac{3}{4}$	6.54	6.59 Double set of measures.
	26	9 $\frac{1}{2}$	6.54	6.47 "
	30	8 $\frac{1}{2}$	6.42	6.46 "
	31	9	6.55	6.54 "
Apr.	1	8 $\frac{1}{2}$	6.30	Measured.
	3	8 $\frac{1}{2}$	6.58	6.52 Double set of measures.
	6	9	6.64	Measured.
	7	8 $\frac{1}{2}$	6.64	Estimated.
	8	8 $\frac{1}{2}$	6.46	Estimated; misty.
	11	8 $\frac{1}{2}$	6.57	Estimated.
	12	9 $\frac{1}{4}$	6.50	Measured.
	16	9	6.77	"
	20	9	6.65	"
	22	8 $\frac{3}{4}$	6.55	Or less estimated.

The variation is undoubted, but the period seems to be irregular, or the observations not sufficient to determine it. This star is P. vii. 116 and Σ 1097. The magnitude of the bright companion being given by Σ as 6.5, but by Heis as 6. The first measures of *U Monocerotis* were made with the photometer on Feb. 14. Observations previous to this were made by estimations with an opera-glass. Occasionally two sets of measures were made, each measure being repeated three times.

U Monoc., R.A. 7^h 24^m 50^s, Dec. 9° 31' 0 (1875).

Date. 1883.	Mag.		Date. d	h	Mag.	
Jan. 15	6.65	Estimated.	Feb. 22		6.78	Measured.
18	6.60	"	23		6.45	"
19	6.55	"	Mar. 1		6.22	"
26	6.10	"	2		6.20	Estimated.
27	6.00	"	3		6.19	"
30	6.10	"	4		6.19 ⁽¹⁾ 6.19 ⁽²⁾	
Feb. 5	6.40	"	11		6.10	"
10	6.80	"	12		6.40	Measured.
12	6.65	"	13		6.57	"
13	6.50	"	14		6.50	Estimated.
14	6.40	Measured.	15		6.49	Measured.
15	6.72	"	17		6.33	"
18	6.77	"	18		6.53	"
20	6.79	"	23	9 $\frac{3}{4}$	6.84 ⁽¹⁾ 6.84 ⁽²⁾	"

Date.		Mag.			Date.		Mag.	
d	h				d	h		
Mar. 26	9 $\frac{1}{2}$	6.70	6.65	Measured.	Apr. 7	8 $\frac{1}{2}$	7.00	Estimated.
	30	8 $\frac{1}{4}$	6.92	6.91		8	8 $\frac{1}{2}$	7.20
	31	9	6.94	6.98		11	8 $\frac{1}{2}$	7.05
Apr. 1	8 $\frac{1}{2}$	7.18				12	9 $\frac{1}{4}$	6.85
	3	8 $\frac{1}{2}$	7.00	7.05		16	9	6.73
	6	9	7.21			20	9	6.65
						22	8 $\frac{3}{4}$	6.50

From these we obtain as times of maxima—

1883, Jan. 28	6.00 $\pm$	1883, Mar. 7 $\pm$	6.00
Feb. 14	6.40	Mar. 17	6.33

And for times of minima—

1883, Feb. 10	6.80	1883, Mar. 13	6.57
20	6.79	Apr. 6	7.21

At the minimum, March 31–April 11, there were small but well-marked fluctuations in light. The star did not seem hazy during this time, nor was there any perceptible change in the colour, which is yellowish-red. The total number of nights between the first and last observation is ninety-seven, and observations were obtained on forty-one.

West Kirby, Birkenhead :
1883, June 3.

Observations of Occultations of Stars by the Moon 1877-78, and of Phenomena of Jupiter's Satellites 1877, made at the Radcliffe Observatory, Oxford.

(Communicated by E. J. Stone, M.A., F.R.S.)

Occultations of Stars by the Moon.

Ref.	Day of Observation.	Phenomenon.	Moon's Limb.	Instrument.	Power.	G.M.T. of Observation. h m s	Observer.
(a)	1877, Jan. 30	Disapp. ρ Leonis	Bright	10-foot Equatorial	150	10 50 17.7	L.
(b)	30	"	"	Heliometer	80	10 50 18.4	H.B.
(c)	Feb. 26	Reapp. ρ Leonis	Dark	10-foot Equatorial	80	11 55 40.6	L.
(d)		Disapp. Regulus	"	"	150	12 44 4.3	L.
		"	"	Heliometer	80	12 44 2.9	Ed.B.
	26	Reapp. Regulus	Bright	10-foot Equatorial	150	13 49 43.6	L.
		"	"	Heliometer	80	13 49 43.5	Ed.B.
(e)	Apr. 26	Disapp. 85 Virginis	Dark	10-foot Equatorial	150	11 59 33.5	L.
(f)	Aug. 23	Disapp. * about 9 mag.	Eclipsed	"	"	9 45 1.2	L.
		" Lalande 43528-9	"	"	"	10 29 40.3	L.
		" * about 9 mag.	"	"	"	10 44 42.0 $\pm$	L.
		" * " 8 "	"	"	"	10 50 33.2	L.
		" * " 8 "	"	"	"	10 53 27.8	L.
		" * " 9 "	"	"	"	10 54 44.6	L.
		Reapp. * " 10 "	"	"	"	11 9 34.4	L.

Occultations of Stars by the Moon.

Ref.	Day of Observation.	Phenomenon.	Moon's Limb.	Instrument.	Power.	G.M.T. of Observation. h m s	Observer.
(g)	1877, Aug. 23	Reapp. * about 9 mag.	Eclipsed	10-foot Equatorial	150	11 9 53.3 ±	L.
		Disapp. * " 9 "	"	"	"	11 21 2.9	L.
		Reapp. Lalande 43528-9	"	"	"	11 39 9.5 ±	L.
	Nov. 20	Disapp. 16 Tauri	Bright	Heliumeter	80	7 20 11.8	L.
(h)	1878, Feb. 15	" 17 "	"	"	"	7 21 21.6	L.
		" 19 "	"	"	"	7 42 56.1	L.
		" 20 "	"	"	"	7 49 41.5	L.
		" ε Cancri	Imperfect	10-foot Equatorial	150	9 34 3.8	L.
	Mar. 13	" 52 Geminorum	Dark	"	"	10 27 19.3	L.
	16	" A Leonis	Imperfect	Heliumeter	200	9 56 27.0	Fd.B.
		" "	"	10-foot Equatorial	150	9 56 26.9	L.
(k)	16	Reapp. A Leonis	Bright	"	"	10 34 17.4	L.

Remarks.

(a) and (b) Instrument unsteady; windy.

Aug. 23. These occultations observed during the eclipse of the Moon. Lal. 43528-9 noted as about mag. 7.

(e) "10" going out of sight."

(g) The Moon full. All the stars became very faint at disappearance, 17 Tauri being less so than the others. Clouds were passing at the disappearance of 19 Tauri, but the observation is considered satisfactory. At 8^h 38^m 38^s ± G.M.T., two smaller stars were occulted nearly in the same place as 20 Tauri, but they became so faint at disappearance that the exact time could not be noted, although that given must be within two seconds.

(h) Cloudy, but the observation satisfactory. (i) and (k) Instantaneous.

In converting Oxford Mean Solar Times into Greenwich Mean Solar Times the following Longitude has been used, 5^m 2^s.6 W.

Phenomena of Jupiter's Satellites.

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation. h m s	G.M.T. of N.A. h m s	Obs.
(a)	1877, June 20	I.	Tr. E. First contact	10-foot Equatorial	150	13 1 53	13 6 0	Fd.B.
			Bisection	"	"	13 3 58		
			Last contact	"	"	13 6 2		
(b)	July 5	I.	Oc. D. Bisection	Heliometer	200	11 37 13	11 38 0	Fd.B.
			Last contact	"	"	11 38 53		
			Oc. D. First contact	"	"	12 6 11		
(c)	7	III.	Oc. D. First contact	"	"	12 9 10	12 10 0	Fd.B.
			Bisection	"	"	12 13 9		
			Last contact	"	"	12 12 43		
(d)	20	I.	Tr. I. Ext. contact	10-foot Equatorial	150	12 12 43	12 16 0	L.
			Int. contact	"	"	12 17 12		
			Oc. D. First contact	"	"	11 7 4		
(e)	24	II.	Oc. D. First contact	"	"	11 11 43	11 11 0	L.
			Last contact	"	"	9 0 55		
			Tr. E. First contact	Heliometer	200	9 4 54		
(f)	26	II.	Bisection	"	"	9 8 24	9 3 0	Fd.B.
			Last contact	"	"	11 18 51		
			Oc. D. First contact	"	"	11 20 41		
(g)	28	I.	Oc. D. First contact	"	"	11 22 40	11 22 0	Fd.B.
			Bisection	"	"			
			Last contact	"	"			

Phenomena of Jupiter's Satellites.

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation. h m s	G.M.T. of N.A. h m s	Obs.
	1877, July 30	I.	Ec. R. First seen	Heliumeter	200	8 56 32	8 56 37	Fd.B.
			Full brightness	"	"	8 57 13	—	"
	Aug. 5	III.	Ec. R. First seen	10-foot Equatorial	150	8 36 6	8 39 24	L.
			Full brightness	"	"	8 42 5	—	"
	12	III.	Ec. D. Began to fade	"	"	9 50 55	—	L.
			Disappearance	"	"	9 56 25	9 55 32	"
	21	I.	Tr. I. First contact	"	"	8 22 37	8 25 0	L.
			Last contact	"	"	8 26 26		L.
	Sept. 7	I.	Ec. R. First seen	"	"	7 29 18	7 29 7	L.
			Full brightness	"	"	7 31 23	—	"
	22	I.	Tr. E. First seen	Heliumeter	200	7 16 31	7 14 0	Fd.B.
			Last contact	"	"	7 22 0		"
	Oct. 5	II.	Tr. I. First contact	10-foot Equatorial	150	7 17 3	7 17 0	L.
			Last contact	"	"	7 22 32		"
	16	I.	Ec. R. First seen	"	"	6 1 28	6 1 35	L.
			Full brightness	"	"	6 3 25	—	"

Remarks.

(a) Planet ill-defined; observation unsatisfactory.

(b) Images ill-defined and tremulous.

(c) Cloudy. Jupiter's image ill-defined; satellite unusually faint when near the planet. The shadow seen on the apparent lower belt.

Observers :—L. = Mr. Lucas.

Fd.B. = Mr. Frederick Bellamy.

H.B. = Mr. H. Bellamy.

Observations of Occultations of Stars by the Moon, and of Phenomena of Jupiter's Satellites, made at the Radcliffe Observatory, Oxford, 1882-83.

(Communicated by E. J. Stone, M.A., F.R.S.)

Ref.	Day of Observation.	Phenomenon.	Moon's Limb.	Instrument.	Power.	G.M.T. of Observation.		Obs.
						h	m s	
(a)	1882, Mar. 22	Disapp. 53 Arietis	Dark	42-inch telescope	80	10 10	43.6	R.
(b)	Apr. 4	Disapp. ϵ Leonis	Bright	10-foot Equatorial	160	11 33	17.3	R.
(c)	May 29	Disapp. B.A.C. 4700	Dark	"	160	13 1	27.1	R.
(d)	June 7	Reapp. κ Aquarii	"	42-inch telescope	80	12 20	4.8	R.
(e)	Aug. 2	Reapp. 22 Piscium	"	10-foot Equatorial	160	10 50	7.5	F.B.
(f)	Sept. 20	Disapp. μ Sagittarii	"	"	125	9 17	24.7	F.B.
	Oct. 24	Disapp. 51 Piscium	"	"	125	11 49	49.5	F.B.
(g)	1883, Feb. 15	Disapp. B.A.C. 1563	"	Heliometer	200	10 2	22.3	W.
(h)		"	"	10-foot Equatorial	160	10 2	22.2	R.
(i)	16	Disapp. χ^2 Orionis	"	Heliometer	200	5 58	45.8	W.
		"	"	10-foot Equatorial	160	5 58	45.8	R.
(k)		"	"	42-inch telescope	80	5 58	45.5	F.B.
(l)	Mar. 12	Disapp. σ Arietis	"	Heliometer	80	6 49	35.1	W.
(m)		"	"	10-foot Equatorial	160	6 49	35.3	R.
(n)		"	"	42-inch telescope	80	6 49	34.8	F.B.

Remarks.

(a) and (d) Star exceedingly faint; observation difficult; Moon very low. (b) Lost in glare at Moon's limb.

(c) Disappeared instantaneously; observation considered very good. (e) The time noted may be a very little late.

(f), (g), (h), and (i) Instantaneous. (k) and (m) Instantaneous; but chronometer beats faint, noise from bells, &c.

(j) Disappearance instantaneous. Images very steady. "Earth-shine" very distinctly showed markings on the Moon; the star appeared to touch the "Earth-shine" limb at least two seconds before its sudden disappearance.

In converting Oxford Mean Solar Times into Greenwich Mean Solar Times the following Longitude has been used, 5^m 2^s·6 W.

Phenomena of Jupiter's Satellites.

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation.			G.M.T. of N.A.			Obs.
	1882, Jan. 7	II.	Oc. D. Bisection	10 foot Equatorial	160	h	m	s	h	m	s	
	7	III.	Tr. E. Bisection	"	"	7	33	26	7	32	0	W.
			Last contact	"	"	8	23	39	8	26	0	W.
		I.	Tr. I. Ext. contact	"	"	8	32	58				
			Bisection	"	"	8	27	9				
			Int. contact	"	"	8	29	23	8	27	0	W.
			Int. contact	"	"	8	32	4				
	7	I.	Tr. E. Int. contact	"	"	10	35	45				
			Bisection	"	"	10	39	31	10	40	0	W.
			Ext. contact	"	"	10	41	59				
	23	I.	Tr. I. Ext. contact	"	"	6	38	11				
			Bisection	"	"	6	42	26	6	39	0	R.
			Int. contact	"	"	6	46	10				
	23	II.	Tr. I. Bisection	"	"	7	13	36	7	16	0	R.
			Int. contact	"	"	7	17	45				
(a)	24	I.	Ec. R. First seen	"	"	7	23	17	7	23	33	W.
(b)	Feb. 1	III.	Oc. D. Bisection	42-inch telescope	80	7	43	10±	7	45	0	R.
			Last contact	"	"	7	48	24				

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation.	G.M.T. of N.A.	Obs.
	1882, Feb. 1	I	Ec. R. First seen	42-inch telescope	80	9 30 9	9 30 2	R.
		II.	Half brightness	"	"	9 31 22	—	"
			Full brightness	"	"	9 33 22	—	"
		I	Oc. R. First contact	"	"	9 38 51	9 49 0	R.
			Bisection	"	"	9 43 20		
			Last contact	"	"	9 46 50	6 50 45	R.
	15	I.	Tr. I. First contact	"	"	6 50 45		
			Bisection	"	"	6 55 25		
			Last contact	"	"	7 2 48	7 8 16	R.
	" 24	II.	Tr. I. Ext. contact	10-foot Equatorial	160	7 8 16		
			Bisection	"	"	7 11 16	7 11 0	
			Int. contact	"	"	7 14 45	7 30 0	R.
	Mar. 3	I.	Tr. E. Int. contact	"	"	7 27 9		
			Bisection	"	"	7 29 23		
			Ext. contact	"	"	7 32 38	7 45 0	R.
	Apr. 3	III.	Tr. I. Ext. contact	Heliumeter	200	7 41 57		
			Bisection	"	"	7 49 25		
			Int. contact	"	"	7 58 4	8 12 18	R.
	3	I.	Ec. R. First seen	"	"	8 12 29		
			Full brightness	"	"	8 15 30±	—	"

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation.	G.M.T. of N.A.	Obs.
						h m s	h m s	
(c)	1882, Apr. 6	II.	Ec. R. First seen	Heliumeter	200	8 57 54	8 57 40	W.
			Half brightness	"	"	8 59 23	—	"
	6	II.	Full brightness	"	"	9 1 2	—	"
			Ec. R. First seen	10-foot Equatorial	160	8 57 36	8 57 40	R.
			Half brightness	"	"	8 59 11	—	"
	1883, Jan. 26	II.	Full brightness	"	"	9 0 41	—	"
			Ec. R. First seen	"	125	9 16 22	9 16 37	R.
			Full brightness	"	"	9 20 12	—	"
			Tr. I. Ext. contact	"	"	10 17 17	10 21 0	R.
	26	I.	Bisection	"	"	10 20 32		
			Internal contact	"	"	10 24 1		
			Ec. R. First seen	"	160	10 39 11	10 39 33	F.B.
	Feb. 5	I.	Full brightness	"	"	10 41 31	—	"
			Ec. R. First seen	"	"	7 3 57	7 4 5	R.
			Full brightness	"	"	7 7 27 ±	—	"
			Tr. I. Ext. contact	"	"	10 49 40	10 58 0	R.
(d)	5	III.	Bisection	"	"	10 57 19		
			Int. contact	"	"	11 8 42		

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation.	G.M.T. of N.A.	Obs.
(e)	1883, Feb. 5	III.	Tr. I. Ext. contact	Heliometer	200	h m s	h m s	
			Bisection	"	"	10 53 47	10 58 0	F.B.
			Int. contact	"	"	10 59 31		
				"	"	11 6 30		
(f)	9	III.	Ec. R. First seen	"	"	7 49 49	7 52 23	W.
			Half brightness	"	"	7 55 8		"
			Full brightness	"	"	8 1 7		"
	9	III.	Ec. R. First seen	10-foot Equatorial	160	7 49 45	7 52 23	R.
			Full brightness	"	"	8 0 9±		"
	10	I.	Oc. D. Ext. contact	"	"	11 4 25		
			Bisection	"	"	11 7 54±	11 9 0	F.B.
			Last contact	"	"	11 9 54		
	12	I.	Ec. R. First seen	"	"	8 59 30	8 59 45	R.
			Full brightness	"	"	9 2 4±		"
	12	I.	Ec. R. First seen	Heliometer	200	8 59 33	8 59 45	F.B.
	16	III.	Oc. R. Last contact	"	"	7 0 35	7 3 0	W.
	16	III.	Oc. R. Bisection	10-foot Equatorial	125	7 0 20	7 3 0	R.
			Last contact	"	"	7 3 4		
(g)	16	III.	Ec. D. Decided diminution	"	"	9 8 14		R.
			Last seen	"	"	9 15 18	9 13 20	"

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation.	G.M.T. of N.A.	Obs.
						h m s	h m s	
(h)	1883, Feb. 16	III.	Ec. D. Last seen	Heliumeter	200	9 15 34	9 13 20	F.B.
	16	III.	Ec. R. First seen	"	200	11 51 59	11 54 13	W.
			Half brightness	"	80	11 57 1	—	"
			Full brightness	"	80	12 1 45	—	"
(i)	16	III.	Ec. R. First seen	10-foot Equatorial	160	11 51 51	11 54 13	R.
			Full brightness	"	"	11 59 0 ±	—	"
	16	II.	Oc. D. Bisection	Heliumeter	80	11 58 16	11 58 0	W.
			Last contact	"	"	12 0 15		
(k)	16	II.	Oc. D. Bisection	10-foot Equatorial	160	11 56 1	11 58 0	R.
			Last contact	"	"	11 59 40		
	19	I.	Oc. D. First contact	"	"	7 24 8	7 28 0	R.
			Last contact	"	"	7 29 32		
	23	III.	Oc. D. First contact	"	"	8 3 29	8 8 0	F.B.
			Bisection	"	"	8 7 28		
			Last contact	"	"	8 10 13		
	23	III.	Oc. R. First seen	"	"	10 45 2	10 52 0	R.
			Bisection	"	"	10 48 32		
			Ext. contact	"	"	10 51 31		
	23	III.	Ec. D. Last seen	"	"	13 15 52	13 14 14	R.

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation. h m s	G.M.T. of N.A. h m s	Obs.
	1883, Feb. 26	I.	Oc. D. First contact	10-foot Equatorial	160	9 16 4	9 21 0	R.
			Bisection	"	"	9 18 54		
			Last contact	"	"	9 21 53		
	26	I.	Oc. D. First contact	Heliometer	200	9 19 6	9 21 0	F.B.
			Bisection	"	"	9 21 6		
			Last contact	"	"	9 22 20		
	Mar. 15	I.	Tr. E. Int. contact	10-foot Equatorial	160	7 4 49	7 9 0	W.
			Bisection	"	"	7 7 58		
			Ext. contact	"	"	7 10 18		
	30	I.	Ec. R. First seen	Heliometer	200	9 32 17	9 32 20	F.B.
	30	I.	Ec. R. First seen	10-foot Equatorial	160	9 32 11	9 32 20	R.
(l)	31	II.	Ec. R. First seen	Heliometer	200	8 35 28	8 35 14	W.
			Half brightness	"	"	8 38 8	—	"
			Full brightness	"	"	8 40 28	—	"
	31	II.	Ec. R. First seen	10-foot Equatorial	160	8 35 34	8 35 14	F.B.
(m)	31	III.	Ec. D. Brightness had dimin.	Heliometer	200	9 9 53	—	W.
			Half brightness	"	"	9 13 53	—	"
			Last seen	"	"	9 18 25	9 16 41	"
	31	III.	Ec. D. Last seen	10-foot Equatorial	160	9 18 48	9 16 41	F.B.

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation.	G.M.T. of N.A.	Obs.
(n)	1883, Apr. 4	IV.	Ec. D. Had faded	10-foot Equatorial	160	h m s 9 13 21	h m s —	R.
(o)	4	IV.	Last seen	"	"	10 1 28	9 33 54	"
(p)	4	IV.	Ec. D. Last seen	Heliumeter	160	10 14 52	9 33 54	F.B.
	4	IV.	Ec. R. First seen	"	"	10 20 51	10 59 48	F.B.
	6	I.	Oc. D. First contact	10-foot Equatorial	160	7 56 9	8 0 0	R.
			Last contact	"	"	8 1 38		
	6	I.	Oc. D. First contact	Heliumeter	"	7 56 35	8 0 0	F.B.
			Last contact	"	"	8 0 49		
(q)	6	I.	Ec. R. First seen	10-foot Equatorial	"	11 28 7	11 28 3	R.
	7	III.	Oc. D. First contact	"	"	8 14 14	8 20 0	F.B.
			Bisection	"	"	8 16 58		
			Last contact	"	"	8 20 13		
	7	III.	Oc. R. First contact	"	"	11 6 41	11 11 0	W.
			Last contact	"	"	11 12 40		
	7	III.	Oc. R. First contact	Heliumeter	"	11 8 36	11 11 0	F.B.
			Ext. contact	"	"	11 13 20		
	7	II.	Ec. R. First seen	10-foot Equatorial	"	11 11 13	11 10 38	W.
			Half brightness	"	"	11 13 25	—	"
			Fall brightness	"	"	11 15 9	—	"
	7	II.	Ec. R. First seen	Heliumeter	"	11 11 24	11 10 38	F.B.

Ref.	Day of Observation.	Satellite.	Phenomenon.	Instrument.	Power.	G.M.T. of Observation.			G.M.T. of N.A.			Obs.	
						h	m	s	h	m	s		
(s)	1883, Apr. 14	II.	Oc. D. First contact	10-foot Equatorial	125	8	38	25	}	8	44	o	F.B.
			Last contact	"	"	8	44	54					
	25	III.	Tr. E. Int. contact	"	"	9	53	13	}	9	56	o	F.B.
			Bisection	"	"	9	56	12					
			Ext. contact	"	"	10	0	42					

Remarks.

- (a) Bad definition at times, but observation fair.
 (c) Jupiter boiling. Time of first appearance caught as the faintest trace.
 (e) Images diffused at times. Internal contact fair.
 (f) Slightly hazy at times, but not sufficient to interfere perceptibly with observations.
 (h) Hazy, but faintest trace detected at the time 'First seen.'
 (k) Observations approximate.
 (n) The time $10^h 1^m 28^s$ G.M.T. was when the satellite was *certainly* last seen by me; but I believe this to be early, as I thought I saw it again several times afterwards, and extending over three or four minutes of time. Observed with Jupiter *in* the field of view (R.)
 (o) At $9^h 58^m$ G.M.T. the satellite had disappeared, when Jupiter was in the field; I continued to watch near the place, and happened to look in when Jupiter was just disappearing from the field, and then caught sight of the satellite, which was still shining distinctly. Gazed until $10^h 15^m 52^s$, when all trace of it had entirely disappeared. At $10^h 13^m 52^s$ it was only just visible. The time noted for disappearance is considered good (F.B.) The satellite (J. IV.) must have been about $1^h 15^m$ entering the shadow of Jupiter.
 (p) After having entered the times and notes, &c., in observing book, I went to telescope again, and then saw a very faint trace of the satellite—this was at $11^h 20^m 51^s$ G.M.T.—but it was certainly brighter than when last seen at disappearance; I consider the time noted "First seen" is not more than two minutes late (F.B.)
 (q) Images very bad.

(s) Sky very hazy.

(r) Limbs diffused and tremulous.

F.B. = Mr. Frank Bellamy.

R. = Mr. Robinson.

Observers.—W. = Mr. Wickham.

Phenomena of Jupiter's Satellites observed at Mr. E. Crossley's Observatory, Bermerside, Halifax, during the Opposition 1882-3.
By J. Gledhill.

Date.	Phenomena.	G.M.T.	Time in N. Almanac.	Remarks.
1882.		h m s	h m s	
Nov. 11	I. Tr. I. First contact	9 38 0	9 37 0	Definition poor to-night.
	Inner contact	42 0		
	I. Sh. E. Just off	10 57 0	11 0 0	
	I. Tr. E. Inner contact	11 49 0	11 52 0	
	Outer contact	52 0		
14	II. Tr. I. First contact	11 8 0	11 9 0	Much tremulous motion.
	Inner contact	11 0		
	II. Sh. E. Inner contact	12 15 0	12 15 0	
	Just off	18 0		
27	I. Sh. E. Just off?	9 18 0	9 17 0	Very bad definition.
	I. Tr. E. Inner contact	9 46 0	9 48 0	
	Outer contact	48 0		
1883.				
Jan. 20	I. Ec. R. First seen	8 43 45	8 44 5	Good observation.
29	III. Tr. I. First contact	7 23 0	7 25 0	
	Bisection	29 0		
	Inner contact	32 0		
Feb. 4	I. Tr. E. Inner contact	8 47 0	8 51 0	
	Bisection	50 0		
	Just off	52 0		
11	I. Tr. E. Just off	10 41 0	10 41 0	Clouds interrupted the observations.
12	I. Ec. R. First seen	8 59 28	8 59 45	
27	*II. Ec. R. First seen	8 55 54	8 56 0	Fairly good observations.
	* Full orb	8 58 0		
Mar. 14	I. Ec. R. First seen	11 11 43	11 11 46	
	Full orb	15 0		
23	I. Ec. R. First seen	7 36 25	7 36 34	
	Full orb	40 0		
31	I. Sh. E. First contact	6 42 0	6 47 0	
	Bisection	44 0		
	Just off	46 0		

* Mr. Crossley was at the telescope during the observations thus marked.

Date.	Phenomena.	G.M.T.	Time in <i>N. Almanac.</i>			Remarks.
			h	m	s	
1883.						
Mar. 31	III. Oc. R. Half out	6 50 0	6	58	0	
	Just off	52 0				
	II. Ec. R. First seen	8 35 21	8	35	14	
	Full orb	39 0				
	III. Ec. D. Fading?	9 10 0	9	16	41	
	Certainly fading	9 11 0				
	Fading fast	9 12 0				
	Half gone	9 14 0				
	Easily seen	9 18 0				
	Just gone	9 19 26				
	III. Ec. R. First seen	12 3 22	12	4	49	
Apr. 6	I. Oc. D. Outer contact	7 57 30	8	0	0	Good sky.
	Bisection	8 0 0				
	Gone	8 2 0				
	I. Ec. R. First seen	11 28 0	11	28	3	
	Full orb	11 31 0				Uncertain; planet low.
7	I. Tr. E. Inner contact	7 26 0	7	29	0	Fair observations.
	Bisection	28 0				
	Outer contact	30 0				
	III. Oc. D. First contact	8 17 0	8	20	0	Fair observations.
	Bisection	21 0				
	Just gone	23 0				
	I. Sh. E. Inner contact	8 35 0	8	42	0	Uncertain observations; misty.
	Bisection?	37 0				
	Off?	39 0				
16	II. Sh. E. Inner contact	8 35 0	8	43	0	Windy; cloudy.
	Just off	8 40 0				
22	I. Ec. R. First seen	9 48 0	9	48	8	Cloudy.
	Half light	50 0				
	Full	53 0				

Ephemeris for Physical Observations

Greenwich Noon.	Angle of Position of ☿'s Axis.	Latitude of Earth Sun above ☿'s Equator.		Δ-L.	O-L.	Longitude of ☿'s Central Meridian.	Cor. for Phase.
1883.	°	°	°	°	°	°	°
Sept. 16	13°340	+ 1°115	+ 1°346	- 9°066	16°876	184°70	+ 0°36
21	13°662	1°079	1°326	9°482	16°048	216°29	°39
26	13°963	1°044	1°306	9°853	15°265	247°95	°42
Oct. 1	14°243	1°010	1°285	10°176	14°531	279°67	°45
6	14°501	+ 0°977	+ 1°265	- 10°448	13°849	311°45	+ 0°47
11	14°736	°945	1°245	10°664	13°223	343°30	°49
16	14°947	°915	1°225	10°821	12°655	15°21	°51
21	15°133	°886	1°205	10°915	12°150	47°19	°52
26	15°294	°858	1°185	10°943	11°713	79°24	°52
31	15°428	°832	1°164	10°900	11°347	111°36	°52
Nov. 5	15°535	+ 0°808	+ 1°144	- 10°783	11°054	143°56	+ 0°51
10	15°614	°786	1°124	10°590	10°838	175°83	°49
15	15°664	°767	1°103	10°317	10°702	208°17	°46
20	15°685	°750	1°083	9°963	10°647	240°58	°43
25	15°677	°735	1°063	9°527	10°675	273°05	°39
30	15°639	°722	1°042	9°008	10°786	305°59	°35
Dec. 5	15°571	+ 0°712	+ 1°021	- 8°408	10°979	338°20	+ 0°31
10	15°475	°705	1°001	7°728	11°251	10°87	°26
15	15°351	°700	0°980	6°973	11°599	43°58	°21
20	15°200	°698	°959	6°146	12°019	76°33	°16
25	15°023	°698	°939	5°254	12°505	109°12	°12
30	14°824	°700	°918	4°304	13°049	141°93	°08
1884.							
Jan. 4	14°605	+ 0°704	+ 0°897	- 3°307	13°640	174°76	+ 0°05
9	14°370	°710	°876	2°273	14°268	207°59	°02
14	14°124	°718	°856	1°214	14°922	240°40	+ °01
19	13°870	°727	°835	- 0°140	15°591	273°19	°00
24	13°612	°736	°814	+ 0°935	16°262	305°94	°00
29	13°356	°747	°793	1°993	16°921	338°64	- °02

of Jupiter, 1883-84. By A. Marth.

Greenwich Noon.	Diameter Equat. Polar.		Difference of limbs in A. R. in Decl.		Defect of illumination. Equat. in A. R. preced. limb.		d	w
1883.	"	"	s	"	"	s	o	o
Sept. 16	34'14	31'97	2'425	32'09	0'21	0'015	9'07	268'34
21	34'53	32'33	2'450	32'46	'24	'016	9'49	268'30
26	34'95	32'72	2'477	32'85	'26	'018	9'86	268'27
Oct. 1	35'39	33'14	2'506	33'28	'28	'019	10 18	268'24
6	35'86	33'58	2'536	33'72	0'30	0'020	10'45	268'21
11	36'36	34'04	2'568	34'19	'31	'021	10'66	268'18
16	36'88	34'53	2'603	34'69	'33	'022	10'82	268'14
21	37'42	35'04	2'640	35'20	'34	'023	10'92	268'11
26	37'98	35'56	2'678	35'74	'35	'023	10'95	268'07
31	38'56	36'11	2'717	36'29	'35	'023	10'91	268'04
Nov. 5	39'16	36'67	2'758	36'85	0'35	0'023	10'79	268'00
10	39'77	37'23	2'800	37'42	'34	'023	10'59	267'96
15	40'38	37'81	2'843	38'00	'33	'022	10'32	267'92
20	40'99	38'38	2'886	38'58	'31	'021	9'97	267'87
25	41'60	38'95	2'929	39'15	'29	'019	9'53	267'82
30	42'20	39'51	2'972	39'71	'26	'017	9'01	267'76
Dec. 5	42'78	40'05	3'014	40'25	0'23	0'015	8'41	267'69
10	43'33	40'57	3'055	40'77	'20	'013	7'73	267'61
15	43'84	41'05	3'093	41'25	'16	'011	6'98	267'50
20	44'30	41'48	3'128	41'68	'13	'009	6'15	267'35
25	44'71	41'87	3'160	42'06	'09	'006	5'26	267'15
30	45'06	42'20	3'188	42'39	'06	'004	4'31	266'9
1884.								
Jan. 4	45'34	42'46	3'211	42'65	0'04	0'003	3'31	266'4
9	45'55	42'65	3'229	42'83	'02	'001	2'28	265'2
14	45'68	42'76	3'241	42'94	'01	'000	1'22	263'1
19	45'71	42'80	3'248	42'97	following limb		0'18	230'5
24	45'66	42'76	3'248	42'92	'00	'000	0'94	95'1
29	45'53	42'64	3'242	42'79	'01	'001	2'00	91'2

Greenwich Noon.	Angle of Position of M's Axis.	Latitude of Earth Sun above M's Equator.		A-L	O-L	Longitude of M's Central Meridian.	Cor. for Phase.
1884.	°	°	°	°	°	°	°
Feb. 3	13°108	+0°758	+0°772	+3°037	17°556	11°27	-0°04
8	12°872	°768	°751	4°041	18°156	43°83	°08
13	12°652	°778	°730	4°999	18°710	76°31	°11
18	12°452	°788	°709	5°902	19°208	108°70	°15
23	12°277	°797	°688	6°742	19°643	141°00	°20
28	12°129	°804	°667	7°512	20°011	173°20	°25
Mar. 4	12°010	+0°810	+0°646	+8°208	20°306	205°29	-0°29
9	11°922	°815	°625	8°825	20°521	237°29	°34
14	11°867	°818	°604	9°362	20°656	269°18	°38
19	11°845	°819	°583	9°818	20°711	300°98	°42
24	11°855	°819	°561	10°194	20°685	332°68	°45
29	11°898	°817	°540	10°490	20°580	4°29	°48
Apr. 3	11°973	+0°812	+0°519	+10°707	20°397	35°81	-0°50
8	12°078	°805	°498	10°849	20°137	67°25	°51
13	12°212	°797	°477	10°918	19°803	98°62	°52
18	12°374	°787	°455	10°918	19°404	129°92	°52
23	12°561	°774	°434	10°852	18°941	161°15	°51
28	12°772	°759	°413	10°723	18°412	192°32	°50
May 3	13°006	+0°743	+0°392	+10°534	17°824	223°45	-0°48
8	13°259	°725	°370	10°291	17°182	254°53	°46
13	13°530	°704	°349	9°996	16°488	285°56	°43
18	13°816	°682	°328	9°653	15°746	316°56	°40
23	14°117	°658	°307	9°265	14°960	347°52	°37
28	14°430	°632	°285	8°836	14°133	18°46	°34
June 2	14°754	+0°605	+0°264	+8°369	13°268	49°38	-0°31
7	15°087	°576	°243	7°868	12°368	80°28	°27
12	15°426	°545	°222	7°335	11°438	111°17	°23

Greenwich Noon.	Diameter		Difference of limbs		Defect of illumination.		d	w
	Equat.	Polar.	in A.R.	in Decl.	Equat. in A.R. following limb.			
1884.	"	"	s	"	"	s	o	o
Feb. 3	45'32	42'44	3'23I	42'59	0'03	0'002	3'04	90'3
8	45'04	42'17	3'214	42'32	'05	'004	4'04	89'8
13	44'68	41'83	3'19I	41'98	'08	'006	5'00	89'44
18	44'26	41'44	3'163	41'58	'12	'008	5'90	89'22
23	43'79	41'00	3'132	41'13	'15	'010	6'74	89'06
28	43'27	40'51	3'096	40'64	'19	'013	7'51	88'93
Mar. 4	42'71	39'99	3'058	40'11	0'22	0'015	8'21	88'83
9	42'12	39'44	3'017	39'56	'25	'017	8'83	88'75
14	41'52	38'87	2'974	38'99	'28	'019	9'36	88'67
19	40'90	38'29	2'930	38'41	'30	'021	9'82	88'59
24	40'27	37'71	2'885	37'82	'32	'022	10'20	88'52
29	39'65	37'12	2'839	37'23	'33	'023	10'49	88'46
Apr. 3	39'03	36'54	2'794	36'65	0'34	0'024	10'71	88'40
8	38'42	35'97	2'750	36'08	'34	0'24	10'85	88'34
13	37'82	35'42	2'706	35'53	'34	'024	10'92	88'28
18	37'25	34'88	2'663	34'99	'34	'023	10'92	88'21
23	36'69	34'35	2'621	34'47	'33	'023	10'86	88'15
28	36'15	33'85	2'581	33'97	'32	'022	10'73	88'09
May 3	35'64	33'37	2'542	33'49	0'30	0'021	10'54	88'02
8	35'15	32'91	2'505	33'03	'28	'020	10'30	87'95
13	34'69	32'48	2'469	32'60	'26	'018	10'00	87'88
18	34'25	32'07	2'435	32'20	'24	'017	9'66	87'81
23	33'84	31'69	2'403	31'82	'22	'015	9'27	87'73
28	33'46	31'33	2'372	31'46	'20	'014	8'84	87'64
June 2	33'10	30'99	2'344	31'13	0'18	0'012	8'38	87'55
7	32'77	30'68	2'318	30'83	'15	'011	7'88	87'44
12	32'47	30'40	2'292	30'55	'13	'009	7'34	87'33

The angle $\Lambda - L$ is the difference of the Jovicentric longitudes of the Sun and the Earth, reckoned in the plane of *Jupiter's* equator, $O - L$ the difference of longitudes of *Jupiter's* vernal equinoctial point O and of the point of his equator which is in opposition to the Earth, or $L + 180^\circ - O$ is the Jovicentric longitude of the Earth reckoned from O .

The assumed daily rate of rotation, on which the "Longitude of $\mathcal{U}$'s Central Meridian" depends, is the same as has been adopted in the ephemerides of the last two apparitions—namely, $870^\circ 42'$, the corresponding period being $9^h 55^m 34^s \cdot 47$. Even if it should be found that, since last seen, the great reddish spot has entirely faded away, its place ought to be watched specially, and for the purpose it seems desirable not to make any alteration for the present. In the column "Longitude of $\mathcal{U}$'s Central Meridian" the successive values differ, for an interval of five days, by twelve rotations and some thirty degrees, so that, for instance, the first difference is $4351^\circ 59'$ and the last $4350^\circ 89'$, which must be borne in mind in interpolating. If the "Corr. for Phase" is added to the "Longitude of $\mathcal{U}$'s Central Meridian," or of the meridian directed to the Earth, the longitude of the meridian is found which bisects the illuminated disk of the planet.

The assumed value of *Jupiter's* equatorial diameter is $37'' \cdot 60$ at the distance $5 \cdot 20273$. The assumed proportion of the polar axis to the equatorial diameter is $0 \cdot 9363$. The defect of illumination of the apparent polar diameter is insensible, that of the difference of limbs in declination is $0'' \cdot 02$ from October 6 to November 30 and $0'' \cdot 01$ for the other dates, except from December 25 to February 13, when it is insensible. The last columns give the values of the auxiliary angles d and w required in the computations for defect of illumination, as explained in vol. xi. p. 490 ff.

The following is a list of the Greenwich mean times, when the assumed First Meridian of *Jupiter* passes the middle of the illuminated disk:—

1883.	h	m	1883.	h	m	1883.	h	m	1883.	h	m
Sept. 15	18	53·8	Sept. 20	18	1·5	Sept. 25	17	9·1	Sept. 30	16	16·5
	16	4 49·4		21	3 57·1		26	3 47	Oct. 1	2 12·2	
		14 45·1			13 52·8			13 0·3		12 7·8	
	17	0 40·7			23 48·4			22 55·9		22 3·4	
		10 36·4		22	9 44·0		27	8 51·6		2 7 59·0	
		20 32·0			19 39·7			18 47·2		17 54·6	
	18	6 27·7		23	5 35·3		28	4 42·8		3 3 50·3	
		16 23·3			15 30·9			14 38·4		13 45·9	
	19	2 18·9		24	1 26·5		29	0 34·1		23 41·5	
		12 14·6			11 22·2			10 29·7		4 9 37·1	
		22 10·2			21 17·8			20 25·3		19 32·7	
	20	8 5·9		25	7 13·4		30	6 20·9		5 5 28·3	

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1883.	h	m	1883.	h	m	1883.	h	m	1883.	h	m
Oct. 5	15	23.9	Oct. 22	4	27.8	Nov. 7	17	30.5	Nov. 24	6	32.1
6	1	19.5		14	23.4	8	3	26.1		16	27.7
	11	15.2	23	0	19.0		13	21.7	25	2	23.2
	21	10.8		10	14.6		23	17.2		12	18.7
7	7	6.4		20	10.2	9	9	12.6		22	14.2
	17	2.0	24	6	5.7		19	8.3	26	8	9.8
8	2	57.6		16	1.3	10	5	3.9		18	5.3
	12	53.2	25	1	56.9		14	59.4	27	4	0.8
	22	48.8		11	52.5	11	0	55.0		13	56.3
9	8	44.4		21	48.0		10	50.5		23	51.8
	18	40.0	26	7	43.6		20	46.1	28	9	47.4
10	4	35.6		17	39.2	12	6	41.6		19	42.9
	14	31.2	27	3	34.8		16	37.2	29	5	38.4
11	0	26.8		13	30.3	13	2	32.7		15	33.9
	10	22.4		23	25.9		12	28.2	30	1	29.4
	20	18.0	28	9	21.5		22	23.8		11	24.9
12	6	13.6		19	17.1	14	8	19.3		21	20.4
	16	9.2	29	5	12.6		18	14.9	Dec. 1	7	16.0
13	2	4.8		15	8.2	15	4	10.4		17	11.5
	12	0.4	30	1	3.8		14	6.0		2.3	7.0
	21	56.0		10	59.3	16	0	1.5		13	2.5
14	7	51.6		20	54.9		9	57.0		22	58.0
	17	47.2	31	6	50.5		19	52.6	3	8	53.5
15	3	42.8		16	46.0	17	5	48.1		18	49.0
	13	38.4	Nov. 1	2	41.6		15	43.6		4	44.5
	23	34.0		12	37.2	18	1	39.2		14	40.0
16	9	29.6		22	32.7		11	34.7		5	0 35.5
	19	25.2		2	8 28.3		21	30.2		10	31.0
17	5	20.8		18	23.9	19	7	25.8		20	26.6
	15	16.4	3	4	19.4		17	21.3		6	6 22.1
18	1	11.9		14	15.0	20	3	16.8		16	17.6
	11	7.5		4	0 10.5		13	12.4	7	2	13.1
	21	3.1		10	6.1		23	7.9		12	8.6
19	6	58.7		20	1.7	21	9	3.4		22	4.1
	16	54.3	5	5	57.2		18	59.0	8	7	59.6
20	2	49.9		15	52.8	22	4	54.5		17	55.1
	12	45.5	6	1	48.3		14	50.0	9	3	50.6
	22	41.1		11	43.9	23	0	45.6		13	46.1
21	8	36.7		21	39.4		10	41.1		23	41.6
	18	32.2	7	7	35.0		20	36.6	10	9	37.1

1883.	h	m	1883.	h	m	1884.	h	m	1884.	h	m
Dec. 10	19	32.6	Dec. 27	8	32.2	Jan. 12	11	35.9	Jan. 29	0	35.4
	11	5 28.1		18	27.7		21	31.4		10	30.9
	15	23.6		28	4 23.2		13	7 26.9		20	26.4
	12	1 19.1		14	18.6		17	22.3		30	6 21.9
	11	14.6		29	0 14.1		14	3 17.8		16	17.4
	21	10.1		10	9.6		13	13.3		31	2 12.9
	13	7 5.6		20	5.1		23	8.8		12	8.4
	17	1.1		30	6 0.6		15	9 4.3		22	3.9
	14	2 56.6		15	56.0		18	59.7	Feb. 1	7	59.4
	12	52.1		31	1 51.5		16	4 55.2		17	54.9
	22	47.6		11	47.0		14	50.7		2	3 50.4
	15	8 43.1		21	42.5		17	0 46.2		13	45.9
	18	38.5	1884.				10	41.7		23	41.4
	16	4 34.0	Jan. 1	7	38.0		20	37.1		3	9 36.9
	14	29.5		17	33.4		18	6 32.6		19	32.4
	17	0 25.0		2	3 28.9		16	28.1		4	5 28.0
	10	20.5		13	24.4		19	2 23.6		15	23.5
	20	16.0		23	19.9		12	19.1		5	1 19.0
	18	6 11.5		3	9 15.4		22	14.6		11	14.5
	16	7.0		19	10.8		20	8 10.0		21	10.0
	19	2 2.5		4	5 6.3		18	5.5		6	7 5.5
	12	58.0		15	1.8		21	4 1.0		17	1.1
	21	53.5		5	0 57.3		13	56.5		7	2 56.6
	20	7 49.0		10	52.8		23	52.0		12	52.1
	17	44.4		20	48.2		22	9 47.5		22	47.6
	21	3 39.9		6	6 43.7		19	43.0		8	8 13.1
	13	35.4		16	39.2		23	5 38.4		18	38.7
	23	30.9		7	2 34.7		15	33.9		9	4 34.2
	22	9 26.4		12	30.2		24	1 29.4		14	29.7
	19	21.9		22	25.6		11	24.9		10	0 25.2
	23	5 17.4		8	8 21.1		21	20.4		10	20.8
	15	12.8		18	16.6		25	7 15.9		20	16.3
	24	1 8.3		9	4 12.1		17	11.4		11	6 11.8
	11	3.8		14	7.5		26	3 6.9		16	7.3
	20	59.3		10	0 3.0		13	2.4		12	2 2.9
	25	6 54.8		9	58.5		22	57.9		11	58.4
	16	50.3		19	54.0		27	8 53.4		21	53.9
	26	2 45.7		11	5 49.5		18	48.9		13	7 49.5
	12	41.2		15	44.9		28	4 44.4		17	45.0
	22	36.7		12	1 40.4		14	39.9		14	3 40.5

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1884.	h	m	1884.	h	m	1884.	h	m	1884.	h	m
Feb. 14	13	36.1	Mar. 2	2	38.5	Mar. 18	15	42.7	Apr. 4	4	48.6
	23	31.6		12	34.1		19	1 38.3		14	44.2
15	9	27.2		22	29.7		11	34.0	5	0	39.9
	19	22.7	3	8	25.3		21	29.4		10	35.6
16	5	18.2		18	20.8	20	7	25.2		20	31.2
	15	13.8	4	4	16.4		17	20.9	6	6	26.9
17	1	9.3		14	12.0	21	3	16.5		16	22.6
	11	4.9	5	0	7.6		13	12.1	7	2	18.2
	21	0.4		10	3.2		23	7.8		12	13.9
18	6	56.0		19	58.8	22	9	3.4		22	9.6
	16	51.5	6	5	54.4		18	59.0	8	8	5.2
19	2	47.1		15	50.0	23	4	54.7		18	0.9
	12	42.6	7	1	45.6		14	50.3	9	3	56.6
	22	38.2		11	41.2	24	0	45.9		13	52.3
20	8	33.7		21	36.8		10	41.6		23	47.9
	18	29.3	8	7	32.4		20	37.2	10	9	43.6
21	4	24.8		17	28.0	25	6	32.9		19	39.3
	14	20.4	9	3	23.6		16	28.5	11	5	35.0
22	0	16.0		13	19.2	26	2	24.2		15	30.6
	10	11.5		23	14.8		12	19.8	12	1	26.3
	20	7.1	10	9	10.4		22	15.4		11	22.0
23	6	2.6		19	6.0	27	8	11.1		21	17.7
	15	58.2	11	5	1.6		18	6.7	13	7	13.4
24	1	53.8		14	57.2	28	4	2.4		17	9.0
	11	49.3	12	0	52.8		13	58.0	14	3	4.7
	21	44.9		10	48.4		23	53.7		13	0.4
25	7	40.4		20	44.1	29	9	49.3		22	56.1
	17	36.0	13	6	39.7		19	45.0	15	8	51.8
26	3	31.6		16	35.3	30	5	40.6		18	47.4
	13	27.2	14	2	30.9		15	36.3	16	4	43.1
	23	22.7		12	26.5	31	1	32.0		14	38.8
27	9	18.3		22	22.1		11	27.6	17	0	34.5
	19	13.9	15	8	17.7		21	23.3		10	30.2
28	5	9.5		18	13.4	Apr. 1	7	18.9		20	25.9
	15	5.0	16	4	9.0		17	14.6		18	6 21.6
29	1	0.6		14	4.6	2	3	10.3		16	17.3
	10	56.2	17	0	0.2		13	5.9	19	2	12.9
	20	51.8		9	55.8		23	1.6		12	8.6
Mar. 1	6	47.3		19	51.5	3	8	57.2		22	4.3
	16	42.9	18	5	47.1		18	52.9	20	8	0.0

1884.	h	m	1884.	h	m	1884.	h	m	1884.	h	m
Apr. 20	17	55.7	May 3	23	38.2	May 17	5	21.1	May 30	11	4.4
21	3	51.4	4	9	33.9	15	16.8	21	0.1		
13	47.1		19	29.6	18	1	12.5	31	6	55.9	
23	42.8		5	5	25.3	11	8.3	16	51.6		
22	9	38.5	15	21.0	21	4.0	June 1	2	47.3		
19	34.2		6	1	16.7	19	6	59.7	12	43.1	
23	5	29.9	11	12.4	16	55.4	22	38.8	22	38.8	
15	25.6		21	8.1	20	2	51.2	2	8	34.5	
24	1	21.3	7	7	3.9	12	46.9	18	30.3		
11	17.0		16	59.6	22	42.6	3	4	26.0		
21	12.7		8	2	55.3	21	8	38.4	14	21.7	
25	7	8.4	12	51.0	18	34.1	4	0	17.5		
17	4.1		22	46.7	22	4	29.8	10	13.2		
26	2	59.8	9	8	42.4	14	25.5	20	8.9		
12	55.5		18	38.1	23	0	21.3	5	6	4.7	
22	51.2		10	4	33.9	10	17.0	16	0.4		
27	8	46.9	14	29.6	20	12.7	6	1	56.1		
18	42.6		11	0	25.3	24	6	8.4	11	51.9	
28	4	38.3	10	21.0	16	4.2	21	47.6			
14	34.0		20	16.7	25	1	59.9	7	7	43.3	
29	0	29.7	12	6	12.5	11	55.6	17	39.1		
10	25.4		16	8.2	21	51.4	8	3	34.8		
20	21.1		13	2	3.9	26	7	47.1	13	30.5	
30	6	16.8	11	59.6	17	42.8	23	26.3			
16	12.5		21	55.3	27	3	38.5	9	9	22.0	
May 1	2	8.2	14	7	51.0	13	34.3	19	17.7		
12	3.9		17	46.8	23	30.0	10	5	13.5		
21	59.6		15	3	42.5	28	9	25.7	15	9.2	
2	7	55.3	13	38.2	19	21.5	11	1	4.9		
17	51.0		23	33.9	29	5	17.2	11	0.7		
3	3	46.7	16	9	29.6	15	12.9	20	56.4		
13	42.5		19	25.4	30	1	8.7	12	6	52.1	

According to observations made last April by Mr. Denning, the centre of the very much faded reddish spot followed the First Meridian of the Ephemeris about 1^h 34^m. In case the slackening of the motion has continued, the spot or its place will be near the centre of the disk, when observations become again feasible, about two hours after the times in the foregoing list.

Ephemerides of the Satellites of Saturn, 1883-84.
By A. Marth.

The following ephemerides of the five inner satellites are founded upon the same elements as those for the preceding apparition, which were published in the last volume of the *Monthly Notices*. The five satellites deviate so little from the plane of the ring, that it will be most suitable to treat their deviations as latitudes above this plane, the ascending node N and inclination J of which in reference to the plane of the Earth's equator being here assumed:—

1883, Aug. 27	N = 126°4833	J = 7°0119
Sept. 26	4852	0116
Oct. 26	4880	0115
Nov. 25	4921	0113
Dec. 25	4965	0110
1884, Jan. 24	4997	0105
Feb. 23	5015	0101
Mar. 24	126°5032	7°0099

the longitudes N being reckoned from the point of the true equinox.

The assumed longitudes of the satellites in their orbits (i.e. their longitudes from the ascending node added to the right ascension N of the ascending node), referring to the time when the light arrives at the distance, the logarithm of which is 0.950, are the following:—

Ch Gr.	Mimas.	Enceladus.	Tethys.	Dione.	Rhea.
1883, Aug. 27	129°657	185°881	202°304	82°635	269°080
Sept. 26	69°389	147°838	163°249	68°687	139°785
Oct. 26	9°122	109°795	124°194	54°739	10°490
Nov. 25	308°856	71°752	85°138	40°791	241°194
Dec. 25	248°590	33°708	46°083	26°843	111°899
1884, Jan. 24	188°326	355°665	7°027	12°894	342°603
Feb. 23	128°063	317°622	327°972	358°946	213°308
Mar. 24	67°801	279°579	288°917	344°998	84°013

In the following tables P denotes the position-angle of the minor axis of the ring, $L + 180^\circ$ the planetocentric longitude of the Earth referred to the plane of the ring; $\Lambda + 180^\circ$ that of the Sun, or $\Lambda - L$ the difference between the two. The apparent equatorial diameter of the ball and the diameter of the outer rim of the ring depend on Bessel's determinations. The assumed proportion of the polar axis of the ball to the equatorial diameter is 0.900.

In the tables for the satellites a and b are the semi-axes of the apparent orbits, their values depending on Bessel's determination of the major axis of the orbit of *Titan*, and $l-L$ are the longitudes of the satellites in their orbits reckoned from the points which are in superior conjunction with the planet's centre, or are in opposition to the Earth in longitude. By adding to $l-L$ the value of L from the first table, the longitudes l are found.

The values of P , a , b and $l-L$ are to be interpolated for the times for which the apparent positions of the satellites are required, and the rectangular coordinates x and y , reckoned parallel to the axes of the ring and expressed in seconds of arc, or if polar-coordinates are wanted, the position-angles p and distances s of the satellites in reference to the centre of the planet are then found by

$$s \sin (p-P) = x = a \sin (l-L).$$

$$s \cos (p-P) = y = b \cos (l-L).$$

Ch Gr.	P	L	Latitude of Earth Sun above plane of ring.		$\Lambda-L$
			°	°	
1882.	°	°	°	°	°
Aug. 27	355°912	69°759	-25°947	-25°267	-7°003
Sept. 1	355°886	69°991	25°951	25°297	7°034
6	355°866	70°176	25°951	25°326	7°017
11	355°851	70°312	25°948	25°355	6°952
16	355°842	70°399	25°941	25°384	6°837
21	355°838	70°436	25°931	25°412	6°672
26	355°840	70°422	25°919	25°440	6°456
Oct. 1	355°848	70°357	-25°904	-25°468	-6°188
6	355°861	70°242	25°886	25°496	5°871
11	355°879	70°079	25°865	25°524	5°505
16	355°903	69°869	25°841	25°551	5°093
21	355°932	69°614	25°815	25°578	4°635
26	355°965	69°319	25°788	25°605	4°137
31	356°003	68°985	25°758	25°631	3°600
Nov. 5	356°045	68°618	-25°727	-25°657	-3°029
10	356°091	68°222	25°694	25°683	2°430
15	356°139	67°803	25°659	25°709	1°807
20	356°189	67°366	25°623	25°734	1°167
25	356°240	66°919	25°587	25°759	-0°516
30	356°293	66°466	25°551	25°784	+0°141

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c ^h Gr.	P	L	Latitude of Earth Sun above plane of ring.		A-L
			°	°	
1882.	°	°	°	°	°
Dec. 5	356°345	66°015	-25°515	-25°808	+0°796
10	356°396	65°573	25°481	25°832	1°442
15	356°446	65°145	25°450	25°856	2°074
20	356°494	64°737	25°421	25°880	2°685
25	356°538	64°356	25°394	25°903	3°270
30	356°579	64°007	25°372	25°926	3°824

1884.					
Jan. 4	356°616	63°695	-25°355	-25°949	+4°342
9	356°648	63°423	25°343	25°971	4°818
14	356°675	63°195	25°336	25°993	5°251
19	356°696	63°014	25°335	26°015	5°637
24	356°711	62°881	25°341	26°037	5°975
29	356°721	62°798	25°354	26°058	6°263

Feb. 3	356°724	62°767	-25°372	-26°079	+6°499
8	356°721	62°788	25°397	26°100	6°683
13	356°712	62°861	25°429	26°120	6°815
18	356°697	62°985	25°466	26°140	6°897
23	356°676	63°160	25°509	26°160	6°928
28	356°649	63°384	25°557	26°180	6°910

Mar. 4	356°616	63°655	-25°609	-26°199	+6°844
9	356°578	63°972	25°666	26°218	6°733
14	356°535	64°332	25°726	26°237	6°578
19	356°487	64°734	25°789	26°256	6°382
24	356°435	65°175	-25°854	-26°274	+6°147

c ^h Gr.	Diameter of Ball.			Axis of Ring.		Mimas.			
	Equat.	Phase prec. l.	Polar	Major.	Minor.	a ₁	b ₁	l ₁ -L	Diff.
1883.	"	"	"	"	"	"	"	°	°
Aug. 27	17°82	0°067	16°40	41°08	17°98	28°02	-12°26	59°42	1909°90
Sept. 1	17°98	°068	16°55	41°46	18°14	28°28	12°38	169°32	1909°95
6	18°15	°068	16°70	41°84	18°31	28°54	12°49	279°27	1910°00
11	18°32	°067	16°85	42°23	18°48	28°81	12°60	29°27	°05
16	18°49	°066	17°01	42°62	18°64	29°07	12°72	139°32	°10
21	18°66	°063	17°16	43°01	18°81	29°34	12°83	249°42	°15
26	18°82	°060	17°32	43°39	18°97	29°60	12°94	359°57	°18

Ch Gr.	Diameter of Ball.			Axis of Ring.		Mimas.			Diff.	
	Equat.	Phase prec. l.	Polar	Major.	Minor.	a_1	b_1	$l_1 - L$		
1883.	"	"	"	"	"	"	"	"	"	
Oct.	I	18'99	0'055	17'47	43'77	19'12	29'86	-13'04	109'75	1910'22
	6	19'15	0'050	17'61	44'14	19'27	30'11	13'14	219'97	'27
	11	19'30	0'044	17'75	44'49	19'41	30'35	13'24	330'24	'30
	16	19'44	0'038	17'89	44'82	19'54	30'58	13'33	80'54	'34
	21	19'58	0'032	18'01	45'13	19'66	30'79	13'42	190'88	'36
	26	19'70	0'026	18'12	45'42	19'76	30'98	13'48	301'24	'39
	31	19'81	0'020	18'22	45'67	19'85	31'15	13'54	51'63	'41
Nov.	5	19'91	0'014	18'31	45'89	19'92	31'30	-13'59	162'04	1910'42
	10	19'99	0'009	18'38	46'07	19'98	31'43	13'63	272'46	'43
	15	20'05	0'005	18'44	46'22	20'01	31'53	13'65	22'89	'43
	20	20'09	0'002	18'47	46'32	20'03	31'59	13'66	133'32	'43
	25	20'12	0'000	18'50	46'37	20'03	31'63	13'66	243'75	'41
	30	20'12	foll. l.	18'50	46'38	20'00	31'64	13'65	354'16	'39
Dec.	5	20'10	0'001	18'48	46'34	19'96	31'61	-13'62	104'55	1910'37
	10	20'07	0'003	18'45	46'26	19'90	31'56	13'58	214'92	'34
	15	20'02	0'007	18'40	46'14	19'83	31'47	13'52	325'26	'30
	20	19'94	0'011	18'33	45'98	19'73	31'36	13'46	75'56	'25
	25	19'85	0'016	18'25	45'77	19'63	31'22	13'39	185'81	'21
	30	19'75	0'022	18'15	45'53	19'51	31'06	13'31	296'02	'16
1884.										
Jan.	4	19'63	0'029	18'04	45'25	19'38	30'87	-13'22	46'18	1910'10
	9	19'50	0'035	17'92	44'95	19'24	30'66	13'12	156'28	1910'05
	14	19'36	0'041	17'79	44'62	19'10	30'44	13'02	266'33	1909'99
	19	19'21	0'047	17'65	44'27	18'95	30'20	12'92	16'32	'94
	24	19'05	0'052	17'51	43'91	18'79	29'95	12'82	126'26	'87
	29	18'88	0'056	17'36	43'53	18'64	29'69	12'71	236'13	'82
Feb.	3	18'72	0'060	17'20	43'14	18'49	29'43	-12'61	345'95	1909'76
	8	18'55	0'063	17'05	42'75	18'34	29'16	12'51	95'71	'71
	13	18'38	0'065	16'89	42'36	18'19	28'90	12'41	205'42	'65
	18	18'21	0'065	16'74	41'97	18'05	28'63	12'31	315'07	'60
	23	18'04	0'065	16'58	41'58	17'91	28'37	12'22	64'67	'55
	28	17'87	0'064	16'43	41'20	17'78	28'11	12'13	174'22	'50
Mar.	4	17'71	0'063	16'29	40'83	17'65	27'85	-12'04	283'72	1909'46
	9	17'56	0'061	16'15	40'48	17'53	27'61	11'96	33'18	'42
	14	17'41	0'057	16'01	40'14	17'42	27'38	11'88	142'60	'39
	19	17'27	0'053	15'88	39'81	17'32	27'15	11'81	251'99	'35
	24	17'13	0'049	15'76	39'50	17'22	26'94	-11'75	1'34	

*Enceladus.**Tethys.*

o ^b Gr.	α_2	b_2	l_2-L	Diff.	α_3	b_3	l_3-L	Diff.
1883.	"	"	"	"	"	"	"	"
Aug. 27	35° 95'	-15° 73'	115° 77'	1313° 56'	44° 50'	-19° 47'	132° 31'	953° 34'
Sept. 1	36° 28'	15° 88'	349° 33'	.61	44° 91'	19° 65'	5° 65'	.40
6	36° 61'	16° 02'	222° 94'	.65	45° 32'	19° 83'	239° 05'	.45
11	36° 95'	16° 17'	96° 59'	.70	45° 74'	20° 02'	112° 50'	.49
16	37° 29'	16° 31'	330° 29'	.74	46° 17'	20° 20'	345° 99'	.54
21	37° 63'	16° 46'	204° 03'	.79	46° 59'	20° 37'	219° 53'	.59
26	37° 97'	16° 60'	77° 82'	.84	47° 01'	20° 55'	93° 12'	.64
Oct. 1	38° 30'	-16° 73'	311° 66'	1313° 88'	47° 42'	-20° 71'	326° 76'	953° 68'
6	38° 62'	16° 86'	185° 54'	.93	47° 81'	20° 87'	200° 44'	.73
11	38° 93'	16° 98'	59° 47'	1313° 96'	48° 20'	21° 03'	74° 17'	.77
16	39° 22'	17° 10'	293° 43'	1314° 00'	48° 56'	21° 17'	307° 94'	.81
21	39° 50'	17° 20'	167° 43'	.04	48° 89'	21° 29'	181° 75'	.85
26	39° 75'	17° 29'	41° 47'	.06	49° 20'	21° 40'	55° 60'	.87
31	39° 97'	17° 37'	275° 53'	.08	49° 48'	21° 50'	289° 47'	.90
Nov. 5	40° 16'	-17° 43'	149° 61'	1314° 11'	49° 71'	-21° 58'	163° 37'	953° 92'
10	40° 32'	17° 48'	23° 72'	.12	49° 91'	21° 64'	37° 29'	.94
15	40° 44'	17° 51'	257° 84'	.12	50° 07'	21° 68'	271° 23'	.94
20	40° 53'	17° 53'	131° 96'	.12	50° 17'	21° 70'	145° 17'	.95
25	40° 58'	17° 53'	6° 08'	.11	50° 23'	21° 69'	19° 12'	.95
30	40° 59'	17° 51'	240° 19'	.11	50° 24'	21° 67'	253° 07'	.93
Dec. 5	40° 56'	-17° 47'	114° 30'	1314° 08'	50° 20'	-21° 63'	127° 00'	953° 92'
10	40° 49'	17° 42'	348° 38'	.05	50° 12'	21° 56'	0° 92'	.90
15	40° 38'	17° 35'	222° 43'	1314° 02'	49° 98'	21° 48'	234° 82'	.86
20	40° 23'	17° 27'	96° 45'	1313° 99'	49° 80'	21° 38'	108° 68'	.83
25	40° 05'	17° 18'	330° 44'	.94	49° 58'	21° 26'	342° 51'	.79
30	39° 84'	17° 07'	204° 38'	.90	49° 32'	21° 13'	216° 30'	.75
1884.								
Jan. 4	39° 60'	-16° 96'	78° 28'	1313° 85'	49° 02'	-20° 99'	90° 05'	953° 70'
9	39° 34'	16° 84'	312° 13'	.79	48° 69'	20° 84'	323° 75'	.66
14	39° 05'	16° 71'	185° 92'	.74	48° 34'	20° 68'	197° 41'	.60
19	38° 74'	16° 58'	59° 66'	.68	47° 96'	20° 52'	71° 01'	.54
24	38° 42'	16° 45'	293° 34'	.63	47° 57'	20° 36'	304° 55'	.49
29	38° 09'	16° 31'	166° 97'	.58	47° 16'	20° 19'	178° 04'	.44

<i>Enceladus.</i>					<i>Tethys.</i>			
o ^b Gr.	" ₂	b ₂	l ₂ -L	Diff.	a ₃	b ₃	l ₃ -L	Diff.
1883.	"	"	°	°	"	"	°	°
Feb. 3	37°75	-16°18	40°55	1313°52	46°74	-20°03	51°48	953°38
8	37°41	16°05	274°07	·46	46°31	19°86	284°86	·33
13	37°07	15°92	147°53	·41	45°89	19°70	158°19	·28
18	36°73	15°79	20°94	·36	45°47	19°55	31°47	·22
23	36°39	15°67	254°30	·31	45°05	19°40	264°69	·18
28	36°06	15°56	127°61	·26	44°64	19°26	137°87	·13
Mar. 4	35°73	-15°45	0°87	1313°22	44°24	-19°12	11°00	953°09
9	35°42	15°34	234°09	·18	43°85	18°99	244°09	·04
14	35°12	15°24	107°27	·14	43°48	18°87	117°13	953°09
19	34°83	15°15	340°41	1313°11	43°12	18°76	350°13	952°97
24	34°56	-15°07	213°52		42°78	-18°66	223°10	
<i>Dione.</i>					<i>Rhea.</i>			
o ^b Gr.	a ₄	b ₄	l ₄ -L	Diff.	a ₅	b ₅	l ₅ -L	Diff.
1883.	"	"	°	°	"	"	°	°
Aug. 27	57°00	-24°94	12°71	657°51	79°60	-34°83	199°22	398°26
Sept. 1	57°52	25°17	310°22	·55	80°33	35°15	237°48	·30
6	58°05	25°40	247°77	·60	81°07	35°48	275°78	·36
11	58°59	25°64	185°37	·65	81°82	35°80	314°14	·40
16	59°13	25°87	123°02	·70	82°57	36°12	352°54	·45
21	59°67	26°09	60°72	·75	83°33	36°44	30°99	·50
26	60°20	26°31	358°47	·80	84°07	36°75	69°49	·55
Oct. 1	60°73	-26°53	296°27	657°84	84°81	-37°05	108°04	398°59
6	61°24	26°73	234°11	·89	85°52	37°34	146°63	·65
11	61°73	26°93	172°00	·93	86°20	37°61	185°28	·69
16	62°19	27°11	109°93	657°98	86°85	37°86	223°97	·73
21	62°62	27°27	47°91	658°01	87°45	38°08	262°70	·77
26	63°02	27°41	345°92	·04	88°00	38°28	301°47	·81
31	63°37	27°54	283°96	·07	88°49	38°46	340°28	·83
Nov. 5	63°67	-27°64	222°03	658°10	88°92	-38°60	19°11	398°87
10	63°92	27°71	160°13	·11	89°27	38°70	57°98	·88
15	64°12	27°76	98°24	·13	89°55	38°77	96°86	·89
20	64°26	27°79	36°37	·13	89°74	38°81	135°75	·90
25	64°34	27°79	334°50	·13	89°84	38°80	174°65	·91
30	64°35	27°76	272°63	·12	89°86	38°76	213°56	·90

*Dione.**Rhea.*

Ch Gr.	a_s	b_s	$l_s - L$	Diff.	a_s	b_s	$l_s - L$	Diff.
1883.	"	"	"	"	"	"	"	"
Dec. 5	64°30	-27°70	210°75	658°10	89°79	-38°68	252°46	398°88
10	64°19	27°62	148°85	°09	89°64	38°56	291°34	°87
15	64°02	27°51	86°94	°06	89°40	38°42	330°21	°85
20	63°79	27°38	25°00	658°03	89°08	38°24	9°06	°81
25	63°50	27°23	323°03	657°99	88°68	38°03	47°87	°78
30	63°17	27°07	261°02	°95	88°21	37°80	96°65	°74
1884.								
Jan. 4	62°79	-26°89	198°97	657°91	87°68	-37°55	125°39	398°70
9	62°37	26°69	136°88	°85	87°09	37°28	164°09	°65
14	61°91	26°49	74°73	°81	86°46	37°00	202°74	°60
19	61°43	26°28	12°54	°75	85°78	36°71	241°34	°55
24	60°92	26°07	310°29	°70	85°07	36°41	279°89	°50
29	60°40	25°86	247°99	°65	84°34	36°11	318°39	°45
Feb. 3	59°86	-25°65	185°64	657°60	83°59	-35°82	356°84	398°39
8	59°32	25°44	123°24	°54	82°83	35°53	35°23	°34
13	58°77	25°24	60°78	°49	82°07	35°24	73°57	°29
18	58°23	25°04	358°27	°43	81°32	34°96	111°86	°24
23	57°69	24°85	295°70	°39	80°57	34°70	150°10	°19
28	57°17	24°66	233°09	°35	79°83	34°44	188°29	°14
Mar. 4	56°66	-24°49	170°44	657°30	79°12	-34°20	226°43	398°10
9	56°16	24°32	107°74	°25	78°43	33°97	264°53	°05
14	55°68	24°17	44°99	°21	77°76	33°75	302°58	398°01
19	55°23	24°03	342°20	°18	77°13	33°55	340°59	397°98
24	54°80	-23°90	279°38		76°52	-33°37	18°57	

Approximate Greenwich Mean Times of conjunctions of the satellites with the centre of *Saturn*:

"n" inferior conjunction with centre, or satellite exactly in the direction of the minor axis of the ring, north, moving from the following to the preceding side.

"s" superior conjunction, or satellite south, moving from the preceding to the following side.

1883.	h	1883.	h	1883.	h
Aug. 26	7°3 Te. s.	28	4°7 Te. s.		15°4 Di. s.
	18°2 Rh. n.		6°5 Di. n.	30	2°0 Te. s.
	21°7 Di. s.	29	0°5 Rh. s.	31	0°2 Di. n.
27	6°0 Te. n.		3°3 Te. n.		0°6 Te. n.

1883.	h	1883.	h	1883.	h
Aug. 31	6.7 Rh. n.	Sept. 12	16.5 En. n.	Sept. 22	23.1 En. s.
	23.3 Te. s.		19.4 Mi. s.	23	6.6 Di. s.
Sept. 1	9.1 Di. s.	13	5.8 Te. n.		15.0 Te. s.
	21.9 Te. n.		8.9 En. s.		15.5 Mi. n.
2	12.9 Rh. s.		16.7 Di. n.		15.6 En. n.
	17.9 Di. n.		18.0 Mi. s.	24	8.0 En. s.
	20.6 Te. s.		20.0 Rh. n.		13.6 Te. n.
3	19.3 Te. n.	14	4.5 Te. s.		14.1 Mi. n.
4	2.8 Di. s.		16.6 Mi. s.		15.4 Di. n.
	17.9 Te. s.		17.8 En. s.	25	3.1 Rh. s.
	19.2 Rh. n.	15	1.5 Di. s.		12.3 Te. s.
5	11.6 Di. n.		3.1 Te. n.		12.7 Mi. n.
	16.6 Te. n.		10.3 En. n.		16.9 En. s.
6	12.5 En. s.		15.2 Mi. s.	26	0.3 Di. s.
	15.2 Te. s.	16	1.8 Te. s.		9.3 En. n.
	16.4 Mi. n.		2.2 Rh. s.		10.9 Te. n.
	20.5 Di. s.		10.4 Di. n.		11.3 Mi. n.
7	1.4 Rh. s.		13.8 Mi. s.	27	9.1 Di. n.
	13.9 Te. n.		19.2 En. n.		9.3 Rh. n.
	15.0 Mi. n.	17	0.4 Te. n.		9.6 Te. s.
	21.4 En. s.		11.6 En. s.		9.9 Mi. n.
8	5.3 Di. n.		12.5 Mi. s.		18.2 En. n.
	12.5 Te. s.		19.2 Di. s.	28	8.2 Te. n.
	13.6 Mi. n.		23.1 Te. s.		10.7 En. s.
	13.8 En. n.	18	8.5 Rh. n.		17.9 Di. s.
9	7.6 Rh. n.		11.1 Mi. s.		19.9 Mi. s.
	11.2 Te. n.		20.5 En. s.	29	6.9 Te. s.
	12.2 Mi. n.		21.7 Te. n.		15.5 Rh. s.
	14.2 Di. s.	19	4.1 Di. n.		18.5 Mi. s.
	22.7 En. n.		12.9 En. n.		19.5 En. s.
10	9.8 Te. s.		20.4 Te. s.	30	2.8 Di. n.
	10.8 Mi. n.		21.0 Mi. n.		5.5 Te. n.
	15.2 En. s.	20	12.9 Di. s.		12.0 En. n.
	23.0 Di. n.		14.7 Rh. s.		17.1 Mi. s.
11	7.6 En. n.		19.0 Te. n.	Oct. 1	4.2 Te. s.
	8.5 Te. n.	21	17.7 Te. s.		11.6 Di. s.
	13.8 Rh. s.		21.7 Di. n.		15.7 Mi. s.
	20.8 Mi. s.	22	16.3 Te. n.		20.9 En. n.
12	7.1 Te. s.		16.9 Mi. n.		21.7 Rh. n.
	7.9 Di. s.		20.9 Rh. n.	2	2.8 Te. n.

1883.	h		1883.	h		1883.	h		
Oct. 2	13.3	En. s.	Oct. 11	13.3	Te. n.	Oct. 22	9.2	Mi. s.	
	14.3	Mi. s.		12	10.3	Di. s.		10.0	En. n.
	20.4	Di. n.		11.8	Mi. n.		21.1	Te. n.	
3	1.5	Te. s.		12.0	Te. s.	23	8.9	Di. s.	
	12.9	Mi. s.		19.9	En. n.		18.9	En. n.	
	22.2	En. s.	13	4.6	Rh. s.		19.2	Mi. n.	
4	0.1	Te. n.		10.4	Mi. n.		19.7	Te. s.	
	3.9	Rh. s.		10.6	Te. n.	24	11.3	En. s.	
	5.3	Di. s.		12.3	En. s.		11.4	Rh. n.	
	11.6	Mi. s.		19.1	Di. n.		17.7	Di. n.	
	14.6	En. n.	14	9.0	Mi. n.		17.8	Mi. n.	
	22.8	Te. s.		9.3	Te. s.		18.4	Te. n.	
5	7.1	En. s.		20.3	Mi. s.	25	16.4	Mi. n.	
	10.2	Mi. s.		21.2	En. s.		17.0	Te. s.	
	14.1	Di. n.	15	3.9	Di. s.		20.2	En. s.	
	21.4	Te. n.		7.9	Te. n.	26	2.6	Di. s.	
6	10.0	Rh. n.		10.8	Rh. n.		12.6	En. n.	
	15.9	En. n.		13.6	En. n.		15.0	Mi. n.	
	20.1	Te. s.		18.9	Mi. s.		15.6	Te. n.	
	20.1	Mi. n.	16	6.5	Te. s.		17.6	Rh. s.	
	23.0	Di. s.		12.8	Di. n.	27	11.4	Di. n.	
7	8.4	En. n.		17.5	Mi. s.		13.6	Mi. n.	
	18.7	Te. n.		22.5	En. n.		14.3	Te. s.	
	18.7	Mi. n.	17	5.2	Te. n.		21.5	En. n.	
8	7.8	Di. n.		16.9	Rh. s.	28	12.2	Mi. n.	
	16.2	Rh. s.		21.6	Di. s.		12.9	Te. n.	
	17.2	En. n.	18	3.8	Te. s.		14.0	En. s.	
	17.3	Mi. n.	19	2.5	Te. n.		20.2	Di. s.	
	17.4	Te. s.		6.4	Di. n.		23.8	Rh. n.	
9	9.7	En. s.		23.1	Rh. n.	29	6.4	En. n.	
	15.9	Mi. n.	20	1.1	Te. s.		10.8	Mi. n.	
	16.0	Te. n.		8.7	En. s.		11.6	Te. s.	
	16.6	Di. s.		12.0	Mi. s.	30	5.0	Di. n.	
10	14.6	Mi. n.		15.3	Di. s.		9.4	Mi. n.	
	14.7	Te. s.		23.8	Te. n.		10.2	Te. n.	
	18.6	En. s.	21	10.6	Mi. s.		15.3	En. n.	
	22.4	Rh. n.		17.6	En. s.	31	5.9	Rh. s.	
11	1.5	Di. n.		22.4	Te. s.		7.7	En. s.	
	11.0	En. n.	22	0.1	Di. n.		8.9	Te. s.	
	13.2	Mi. n.		5.3	Rh. s.		13.9	Di. s.	

1883.	h		1883.	h		1883.	h	
Oct. 31	19.4	Mi. s.	Nov. 9	19.3	Te. s.	Nov. 19	17.4	Di. s.
Nov. 1	7.5	Te. n.		21.8	En. s.	20	4.4	Te. n.
	16.6	En. s.	10	3.6	Di. n.		4.4	En. n.
	18.0	Mi. s.		14.3	En. n.		13.3	Rh. n.
	22.7	Di. n.		16.8	Mi. n.		14.2	Mi. s.
2	6.2	Te. s.		17.9	Te. n.		20.8	En. s.
	9.0	En. n.	11	6.7	En. s.	21	2.2	Di. n.
	12.1	Rh. n.		12.4	Di. s.		3.0	Te. s.
	16.6	Mi. s.		12.7	Rh. n.		12.8	Mi. s.
3	4.8	Te. n.		15.4	Mi. n.		13.3	En. n.
	7.5	Di. s.		16.6	Te. s.	22	1.7	Te. n.
	15.2	Mi. s.	12	14.0	Mi. n.		5.7	En. s.
	17.9	En. n.		15.2	Te. n.		11.0	Di. s.
4	3.4	Te. s.		15.6	En. s.		11.5	Mi. s.
	10.3	En. s.		21.3	Di. n.		19.5	Rh. s.
	13.8	Mi. s.	13	8.0	En. n.		22.1	En. n.
	16.3	Di. n.		12.6	Mi. n.	23	0.3	Te. s.
	18.2	Rh. s.		13.9	Te. s.		10.1	Mi. s.
5	2.1	Te. n.		18.8	Rh. s.		14.6	En. s.
	12.4	Mi. s.	14	6.1	Di. s.		19.8	Di. n.
	19.2	En. s.		12.5	Te. n.		22.9	Te. n.
6	0.7	Te. s.	15	11.2	Te. s.	24	7.0	En. n.
	1.1	Di. s.		14.9	Di. n.		8.7	Mi. s.
	11.0	Mi. s.	16	1.0	Rh. n.		21.6	Te. s.
	11.6	En. n.		9.8	Te. n.	25	1.6	Rh. n.
	23.4	Te. n.		17.2	En. s.		4.6	Di. s.
7	0.4	Rh. n.		23.7	Di. s.		7.3	Mi. s.
	9.7	Mi. s.	17	7.1	Mi. n.		15.9	En. n.
	10.0	Di. n.		8.4	Te. s.		18.6	Mi. n.
	20.5	En. n.		10.6	En. n.		20.2	Te. n.
	21.0	Mi. n.		18.4	Mi. s.	26	8.3	En. s.
	22.0	Te. s.	18	3.1	En. s.		13.5	Di. n.
8	8.3	Mi. s.		7.1	Te. n.		17.2	Mi. n.
	13.0	En. s.		7.2	Rh. s.		18.9	Te. s.
	18.9	Di. s.		8.5	Di. n.	27	7.8	Rh. s.
	19.6	Mi. n.		17.0	Mi. s.		15.8	Mi. n.
	20.7	Te. n.		19.5	En. n.		17.2	En. s.
9	5.4	En. n.	19	5.7	Te. s.		17.5	Te. n.
	6.5	Rh. s.		11.9	En. s.		22.3	Di. s.
	18.2	Mi. n.		15.6	Mi. s.	28	9.6	En. n.

1883.	h		1883.	h		1883.	h	
Nov. 28	14.4	Mi. n.	Dec. 7	3.9	Te. n.	Dec. 17	13.9	En. n.
	16.2	Te. s.		7.3	En. s.		15.1	Rh. n.
29	7.1	Di. n.		12.0	Di. n.	18	6.3	En. s.
	13.1	Mi. n.		13.3	Mi. s.		9.3	Mi. n.
	13.9	Rh. n.	8	2.6	Te. s.		10.6	Di. n.
	14.8	Te. n.		11.9	Mi. s.		11.7	Te. n.
	18.5	En. n.		14.5	Rh. n.	19	7.9	Mi. n.
30	10.9	En. s.		16.2	En. s.		10.3	Te. s.
	11.7	Mi. n.		20.9	Di. s.		15.2	En. s.
	13.4	Te. s.	9	1.2	Te. n.		19.4	Di. s.
	15.9	Di. s.		8.6	En. n.		21.3	Rh. s.
Dec. 1	3.4	En. n.		10.5	Mi. s.	20	6.6	Mi. n.
	10.3	Mi. n.		23.9	Te. s.		7.6	En. n.
	12.1	Te. n.	10	5.7	Di. n.		9.0	Te. n.
	19.8	En. s.		9.1	Mi. s.	21	0.1	En. s.
	20.1	Rh. s.		17.5	En. n.		4.3	Di. n.
2	0.7	Di. n.		20.7	Rh. s.		5.2	Mi. n.
	8.9	Mi. n.		22.5	Te. n.		7.6	Te. s.
	10.7	Te. s.	11	14.5	Di. s.		16.5	Mi. s.
	12.2	En. n.		21.2	Te. s.		16.5	En. n.
3	4.7	En. s.	12	19.8	Te. n.	22	3.4	Rh. n.
	7.5	Mi. n.		23.3	Di. n.		3.8	Mi. n.
	9.4	Te. n.	13	2.8	Rh. n.		6.3	Te. n.
	9.6	Di. s.		18.5	Te. s.		8.9	En. s.
	18.8	Mi. s.	14	8.1	Di. s.		13.1	Di. s.
	21.1	En. n.		14.9	Mi. n.		15.1	Mi. s.
4	2.2	Rh. n.		17.1	Te. n.	23	1.4	En. n.
	6.1	Mi. n.		20.1	En. n.		4.9	Te. s.
	8.0	Te. s.	15	9.0	Rh. s.		13.7	Mi. s.
	13.6	En. s.		12.6	En. s.		17.8	En. s.
	18.4	Di. n.		13.5	Mi. n.		21.9	Di. n.
5	6.0	En. n.		15.7	Te. s.	24	3.5	Te. n.
	6.7	Te. n.		17.0	Di. n.		9.6	Rh. s.
	16.0	Mi. s.	16	5.0	En. n.		10.3	En. n.
	22.4	En. s.		12.1	Mi. n.		12.3	Mi. s.
6	3.2	Di. s.		14.4	Te. n.	25	2.2	Te. s.
	5.3	Te. s.		21.4	En. s.		2.7	En. s.
	8.4	Rh. s.	17	1.8	Di. s.		6.7	Di. s.
	14.7	Mi. s.		10.7	Mi. n.		10.9	Mi. s.
	14.9	En. n.		13.0	Te. s.	26	0.8	Te. n.

1883.	h	1884.	h	1884.	h
Dec. 26	9.6 Mi. s.	Jan. 3	20.5 Di. n.	Jan. 13	17.2 Rh. n.
	11.6 En. s.	4	8.4 Mi. n.		21.8 Te. n.
	15.6 Di. n.		9.3 En. n.	14	5.9 Mi. s.
	15.8 Rh. n.		11.3 Te. n.		15.9 En. s.
	23.5 Te. s.		16.4 Rh. n.		19.2 Di. n.
27	4.0 En. n.	5	1.7 En. s.		20.5 Te. s.
	8.2 Mi. s.		5.4 Di. s.	15	4.5 Mi. s.
	22.1 Te. n.		7.0 Mi. n.		8.3 En. n.
28	0.4 Di. s.		10.0 Te. s.		15.8 Mi. n.
	6.8 Mi. s.	6	5.6 Mi. n.		19.1 Te. n.
	12.9 En. n.		8.6 Te. n.		23.3 Rh. s.
	20.8 Te. s.		10.6 En. s.	16	0.8 En. s.
	21.9 Rh. s.		14.2 Di. n.		3.1 Mi. s.
29	5.3 En. s.		22.6 Rh. s.		4.0 Di. s.
	5.4 Mi. s.	7	3.0 En. n.		14.4 Mi. n.
	9.2 Di. n.		4.3 Mi. n.		17.8 Te. s.
	16.7 Mi. n.		7.3 Te. s.	17	9.7 En. s.
	19.4 Te. n.		23.0 Di. s.		12.9 Di. n.
30	4.0 Mi. s.	8	5.9 Te. n.		13.0 Mi. n.
	14.2 En. s.		11.9 En. n.		16.4 Te. n.
	15.3 Mi. n.	9	4.4 En. s.	18	2.1 En. n.
	18.1 Di. s.		4.6 Te. s.		5.5 Rh. n.
	18.1 Te. s.		4.8 Rh. n.		11.7 Mi. n.
31	4.1 Rh. n.		7.9 Di. n.		15.1 Te. s.
	6.6 En. n.	10	3.2 Te. n.		21.7 Di. s.
	13.9 Mi. n.		11.4 Mi. s.	19	10.3 Mi. n.
1884.	16.7 Te. n.		13.2 En. s.		11.0 En. n.
Jan. 1	2.9 Di. n.		16.7 Di. s.		13.7 Te. n.
	12.6 Mi. n.	11	1.9 Te. s.	20	3.4 En. s.
	15.4 Te. s.		5.7 En. n.		6.6 Di. n.
	15.5 En. n.		10.0 Mi. s.		8.9 Mi. n.
2	8.0 En. s.		11.0 Rh. s.		11.7 Rh. s.
	10.3 Rh. s.	12	0.5 Te. n.		12.4 Te. s.
	11.2 Mi. n.		1.5 Di. n.	21	7.5 Mi. n.
	11.7 Di. s.		8.6 Mi. s.		11.0 Te. n.
	14.0 Te. n.		14.6 En. n.		12.3 En. s.
3	0.4 En. n.		23.2 Te. s.		15.4 Di. s.
	9.8 Mi. n.	13	7.0 En. s.	22	4.8 En. n.
	12.7 Te. s.		7.3 Mi. s.		6.1 Mi. n.
	16.8 En. s.		10.4 Di. s.		9.7 Te. s.

1884.	h	1884.	h	1884.	h
Jan. 22	17.9 Rh. n.	Feb. 1	3.6 Mi. s.	Feb. 11	12.5 Mi. s.
23	0.2 Di. n.		11.4 En. s.	12	1.8 Rh. s.
	4.8 Mi. n.		14.1 Di. s.		4.1 Te. s.
	8.3 Te. n.		14.9 Mi. n.		10.5 En. s.
	13.6 En. n.		18.9 Te. n.		11.1 Mi. s.
24	3.4 Mi. n.	2	2.3 Mi. s.		12.9 Di. s.
	6.1 En. s.		3.8 En. n.	13	2.7 Te. n.
	7.0 Te. s.		13.6 Mi. n.		3.0 En. n.
	9.1 Di. s.		17.5 Te. s.		9.7 Mi. s.
	14.7 Mi. s.		23.0 Di. n.		21.8 Di. n.
25	0.1 Rh. s.	3	0.9 Rh. s.	14	1.4 Te. s.
	5.6 Te. n.		12.2 Mi. n.		8.1 Rh. n.
	13.3 Mi. s.		12.7 En. n.		8.3 Mi. s.
	15.0 En. s.		16.2 Te. n.		11.9 En. n.
	17.9 Di. n.	4	7.8 Di. s.	15	0.1 Te. n.
26	4.3 Te. s.		14.8 Te. s.		4.3 En. s.
	7.4 En. n.	5	7.2 Rh. n.		6.6 Di. s.
	11.9 Mi. s.		13.5 Te. n.		7.0 Mi. s.
27	2.8 Di. s.		16.7 Di. n.		22.7 Te. s.
	2.9 Te. n.	6	12.1 Te. s.	16	5.6 Mi. s.
	6.3 Rh. n.	7	1.5 Di. s.		13.2 En. s.
	10.5 Mi. s.		6.7 Mi. n.		14.3 Rh. s.
28	1.6 Te. s.		10.8 Te. n.		15.5 Di. n.
	8.7 En. s.		13.4 Rh. s.		21.4 Te. n.
	9.2 Mi. s.		15.4 En. n.	17	4.2 Mi. s.
	11.6 Di. n.	8	5.3 Mi. n.		5.6 En. n.
29	0.2 Te. n.		7.8 En. s.		20.0 Te. s.
	1.2 En. n.		9.5 Te. s.	18	0.3 Di. s.
	7.8 Mi. s.		10.4 Di. n.		14.1 Mi. n.
	12.5 Rh. s.	9	3.9 Mi. n.		14.5 En. n.
	20.4 Di. s.		8.1 Te. n.		18.7 Te. n.
	22.9 Te. s.		16.7 En. s.		20.5 Rh. n.
30	6.4 Mi. s.		19.2 Di. s.	19	7.0 En. s.
	10.1 En. n.		19.6 Rh. n.		9.2 Di. n.
	21.6 Te. n.	10.	6.8 Te. s.		12.8 Mi. n.
31	2.5 En. s.		9.2 En. n.		17.4 Te. s.
	5.0 Mi. s.		13.8 Mi. s.	20	11.4 Mi. n.
	5.3 Di. n.	11	1.6 En. s.		15.9 En. s.
	18.7 Rh. n.		4.1 Di. n.		16.0 Te. n.
	20.2 Te. s.		5.4 Te. n.		18.0 Di. s.

1884.	h	1884.	h	1884.	h
Feb. 21	2.8 Rh. s.	Feb. 28	11.7 Mi. s.	Mar. 10	13.3 Te. n.
	8.3 En. n.		23.2 Di. s.		22.1 Di. s.
	10.0 Mi. n.	29	4.0 Te. s.	11	11.9 Te. s.
	14.7 Te. s.		10.3 Mi. s.	12	6.9 Di. n.
22	0.8 En. s.		13.7 En. n.		10.6 Te. n.
	2.9 Di. n.	Mar. 1	2.6 Te. n.		11.0 Rh. n.
	8.6 Mi. n.		3.7 Rh. s.	13	9.2 Te. s.
	13.3 Te. n.		6.1 En. s.		15.8 Di. s.
23	7.2 Mi. n.		8.0 Di. n.	14	7.9 Te. n.
	9.0 Rh. n.	2	1.3 Te. s.		17.3 Rh. s.
	9.7 En. s.		15.0 En. s.	15	0.7 Di. n.
	11.7 Di. s.		16.9 Di. s.		6.6 Te. s.
	12.0 Te. s.		23.9 Te. n.	16	5.2 Te. n.
24	2.1 En. n.	3	10.0 Rh. n.		8.0 En. s.
	5.9 Mi. n.		22.6 Te. s.		9.5 Di. s.
	10.7 Te. n.	4	1.7 Di. n.		23.6 Rh. n.
	20.6 Di. n.		21.3 Te. n.	17	3.9 Te. s.
25	4.5 Mi. n.	5	8.8 En. s.		18.4 Di. n.
	9.3 Te. s.		10.6 Di. s.	18	2.6 Te. n.
	11.0 En. n.		16.2 Rh. s.	19	1.2 Te. s.
	15.2 Rh. s.		19.9 Te. s.		3.3 Di. s.
26	3.2 Mi. n.	6	1.3 En. n.		5.8 Rh. s.
	3.4 En. s.		18.6 Te. n.		23.9 Te. n.
	5.4 Di. s.		19.5 Di. n.	20	12.1 Di. n.
	8.0 Te. n.	7	10.2 En. n.		22.6 Te. s.
27	6.6 Te. s.		17.3 Te. s.	21	12.1 Rh. n.
	12.3 En. s.		22.5 Rh. n.		21.0 Di. s.
	13.0 Mi. s.	8	4.3 Di. s.		21.2 Te. n.
	14.3 Di. n.		15.9 Te. n.	22	19.9 Te. s.
	21.5 Rh. n.	9	13.2 Di. n.	23	5.8 Di. n.
28	4.8 En. n.		14.6 Te. s.		18.4 Rh. s.
	5.3 Te. n.	10	4.8 Rh. s.		18.6 Te. n.

By means of this list of conjunctions, approximate values of the coordinates x and y , expressed in semi-diameters of the planet's equator, may be easily found for any other time t in the following little table, the argument of which is the interval τ between the time t and the time of the nearest (preceding or following) conjunction. Observers who are desirous to follow the motions of the satellites will do well to lay down the data of the table graphically on a sufficiently large scale, so that by marking the corresponding times for the night of observing, they

may get information about the places of the satellites at a glance. The places change in the direction of *decreasing* position-angles.

τ	<i>Mimas.</i>		<i>Enceladus.</i>		<i>Tethys.</i>		<i>Dione.</i>		<i>Rhea.</i>	
h	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>
0	0.0	1.4	0.0	1.7	0.0	2.2	0.0	2.8	0.0	3.9
1	0.9	1.3	0.8	1.7	0.7	2.1	0.6	2.8	0.5	3.9
2	1.7	1.1	1.5	1.6	1.4	2.1	1.2	2.7	1.0	3.8
3	2.3	0.9	2.2	1.4	2.0	2.0	1.8	2.7	1.5	3.8
4	2.8	0.6	2.8	1.3	2.6	1.8	2.4	2.6	2.0	3.7
5	3.1	0.3	3.3	1.0	3.2	1.6	2.9	2.5	2.5	3.7
6	3.1	0.1	3.7	0.7	3.7	1.4	3.5	2.3	3.0	3.6
7	2.9	0.5	3.9	0.4	4.1	1.2	4.0	2.2	3.5	3.6
8	2.5	0.8	4.0	0.1	4.5	0.9	4.4	2.0	4.0	3.5
9					4.7	0.7	4.8	1.8	4.5	3.4
10					4.9	0.4	5.2	1.6	4.9	3.2
11					5.0	0.1	5.6	1.4	5.3	3.1
12							5.8	1.1	5.7	3.0
13							6.1	0.9	6.1	2.8
14							6.2	0.6	6.5	2.7
15							6.3	0.4	6.8	2.5
16							6.4	0.1	7.1	2.3
18									7.7	1.9
20									8.2	1.5
27									8.9	0.3

The following ephemerides of *Titan* and *Iapetus* give the positions of the two satellites in reference to the circle of declination.

Differences of Right Ascension and Declination between the Satellites Titan and Iapetus, and the Centre of Saturn.

Greenwich, Noon.	<i>Titan.</i>		<i>Iapetus.</i>	
	$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
1883, Aug. 27	+ 11.38 ^s	- 33.3 ["]	- 36.03 ^s	- 111.7 ["]
28	+ 13.09	- 3.4	- 36.05	- 123.9
29	+ 12.91	+ 27.0	- 35.82	- 135.2
30	+ 10.78	+ 53.6	- 35.35	- 145.7
31	+ 6.97	+ 71.8	- 34.65	- 155.2
Sept. 1	+ 2.03	+ 78.6	- 33.71	- 163.7
2	- 3.25	+ 72.5	- 32.53	- 171.1
3	- 8.02	+ 54.2	- 31.13	- 177.4
4	- 11.47	+ 26.9	- 29.52	- 182.6

		<i>Titan.</i>		<i>Iapetus.</i>	
Greenwich, Noon.		$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
1883, Sept.		^h	^m	^s	["]
5		-13°05	- 5°0	-27°70	-186°5
6		-12°55	-36°2	-25°68	-189°2
7		-10°11	-62°1	-23°49	-190°6
8		- 6°13	-78°6	-21°13	-190°8
9		- 1°25	-83°8	-18°62	-189°7
10		+ 3°84	-77°0	-15°98	-187°3
11		+ 8°40	-59°4	-13°22	-183°7
12		+11°79	-33°3	-10°36	-178°9
13		+13°50	- 2°4	- 7°43	-172°9
14		+13°25	+29°0	- 4°43	-165°7
15		+10°99	+56°1	- 1°40	-157°5
16		+ 7°01	+74°5	+ 1°66	-148°2
17		+ 1°88	+80°9	+ 4°72	-138°0
18		- 3°57	+74°0	+ 7°76	-126°8
19		- 8°44	+54°7	+10°77	-114°8
20		-11°93	+26°2	+13°72	-102°0
21		-13°46	- 7°0	+16°60	- 88°6
22		-12°85	-38°7	+19°38	- 74°5
23		-10°25	-64°9	+22°06	- 60°0
24		- 6°09	-81°4	+24°62	- 45°0
25		- 1°03	-86°1	+27°04	- 29°7
26		+ 4°20	-78°5	+29°30	- 14°1
27		+ 8°86	-59°8	+31°39	+ 1°6
28		+12°27	-32°6	+33°31	+17°3
29		+13°93	- 0°6	+35°03	+33°0
30		+13°55	+31°5	+36°55	+48°6
Oct. 1		+11°11	+59°0	+37°86	+63°9
2		+ 6°92	+77°3	+38°96	+79°0
3		+ 1°60	+83°1	+39°83	+93°6
4		- 4°00	+75°1	+40°47	+107°7
5		- 8°95	+54°6	+40°87	+121°3
6		-12°42	+24°9	+41°03	+134°2
7		-13°86	- 9°1	+40°96	+146°4
8		-13°08	-41°7	+40°64	+157°7
9		-10°28	-68°0	+40°09	+168°2
10		- 5°91	-84°1	+39°30	+177°7
11		- 0°67	-88°1	+38°27	+186°2
12		+ 4°69	-79°4	+37°02	+193°7
13		+ 9°40	-59°5	+35°54	+200°0

		<i>Titan.</i>		<i>Iapetus.</i>	
Greenwich, Noon.		$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
1883, Oct. 14		^s + 12'79	["] - 31'1	^s + 33'85	["] + 205'2
	15	+ 14'34	+ 1'8	+ 31'95	+ 209'2
	16	+ 13'78	+ 34'6	+ 29'86	+ 211'9
	17	+ 11'11	+ 62'1	+ 27'58	+ 213'4
	18	+ 6'70	+ 79'9	+ 25'13	+ 213'7
	19	+ 1'19	+ 84'7	+ 22'52	+ 212'6
	20	- 4'54	+ 75'5	+ 19'76	+ 210'2
	21	- 9'51	+ 53'7	+ 16'88	+ 206'6
	22	- 12'91	+ 22'7	+ 13'88	+ 201'6
	23	- 14'19	- 12'1	+ 10'79	+ 195'4
	24	- 13'20	- 45'0	+ 7'63	+ 188'0
	25	- 10'16	- 71'0	+ 4'41	+ 179'4
	26	- 5'58	- 86'5	+ 1'15	+ 169'6
	27	- 0'17	- 89'4	- 2'12	+ 158'7
	28	+ 5'27	- 79'5	- 5'39	+ 146'8
	29	+ 9'98	- 58'3	- 8'63	+ 133'9
	30	+ 13'28	- 28'8	- 11'82	+ 120'0
	31	+ 14'66	+ 4'9	- 14'94	+ 105'3
Nov.	1	+ 13'87	+ 37'1	- 17'97	+ 90'0
	2	+ 10'96	+ 65'2	- 20'89	+ 74'0
	3	+ 6'32	+ 82'1	- 23'67	+ 57'3
	4	+ 0'64	+ 85'7	- 26'29	+ 40'3
	5	- 5'15	+ 75'1	- 28'74	+ 23'0
	6	- 10'08	+ 51'8	- 31'00	+ 5'5
	7	- 13'34	+ 19'8	- 33'05	- 12'1
	8	- 14'40	- 15'5	- 34'88	- 29'7
	9	- 13'16	- 48'4	- 36'46	- 47'1
	10	- 9'88	- 73'8	- 37'79	- 64'2
	11	- 5'10	- 88'3	- 38'86	- 80'9
	12	+ 0'44	- 89'9	- 39'66	- 97'1
	13	+ 5'91	- 78'6	- 40'17	- 112'6
	14	+ 10'55	- 56'2	- 40'40	- 127'3
	15	+ 13'70	- 25'7	- 40'34	- 141'2
	16	+ 14'86	+ 8'4	- 39'99	- 154'1
	17	+ 13'80	+ 41'3	- 39'36	- 165'9
	18	+ 10'65	+ 67'8	- 38'45	- 176'6
	19	+ 5'80	+ 83'6	- 37'26	- 186'0
	20	+ 0'01	+ 85'8	- 35'80	- 194'1
	21	- 5'79	+ 73'7	- 34'08	- 200'8

Greenwich, Noon.	<i>Titan.</i>		<i>Iapetus.</i>	
	$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
1883, Nov. 22	^s -10°61	+49°2	^s -32°12	-206°1
23	-13°66	+16°4	-29°94	-210°0
24	-14°47	-19°0	-27°54	-212°3
25	-12°95	-51°5	-24°94	-213°2
26	-9°44	-76°0	-22°17	-212°6
27	-4°50	-89°1	-19°24	-210°5
28	+1°09	-89°3	-16°18	-207°0
29	+6°53	-76°7	-13°01	-202°0
30	+11°05	-53°2	-9°75	-195°6
Dec. 1	+13°98	-22°2	-6°42	-187°9
2	+14°89	+12°0	-3°05	-178°9
3	+13°57	+44°3	+0°34	-168°7
4	+10°19	+69°8	+3°73	-157°2
5	+5°18	+84°2	+7°09	-144°7
6	-0°66	+84°9	+10°40	-131°3
7	-6°38	+71°3	+13°64	-117°0
8	-11°03	+45°9	+16°79	-102°0
9	-13°83	+12°7	+19°82	-86°3
10	-14°35	-22°1	+22°72	-70°1
11	-12°59	-54°0	+25°48	-53°4
12	-8°88	-77°3	+28°08	-36°4
13	-3°85	-89°0	+30°49	-19°2
14	+1°74	-87°7	+32°71	-1°8
15	+7°08	-73°9	+34°72	+15°5
16	+11°40	-49°7	+36°51	+32°8
17	+14°09	-18°5	+38°08	+49°8
18	+14°74	+15°3	+39°41	+66°5
19	+13°19	+46°8	+40°49	+82°8
20	+9°62	+71°0	+41°33	+98°6
21	+4°53	+83°8	+41°92	+113°7
22	-1°28	+83°0	+42°25	+128°2
23	-6°86	+68°4	+42°33	+141°9
24	-11°29	+42°3	+42°15	+154°7
25	-13°82	+9°2	+41°73	+166°6
26	-14°08	-25°3	+41°05	+177°4
27	-12°11	-55°8	+40°13	+187°2
28	-8°28	-77°6	+38°98	+195°9
29	-3°21	-87°9	+37°60	+203°4
30	+2°31	-85°4	+36°00	+209°6

		Titan.		Iapetus.	
Greenwich, Noon.		$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
1883, Dec.	31	+ 7 ^s .49	- 70 ["] .7	+ 34 ^s .19	+ 214 ["] .6
1884, Jan.	1	+ 11 ^s .59	- 46 ["] .1	+ 32 ^s .18	+ 218 ["] .4
	2	+ 14 ^s .04	- 15 ["] .0	+ 29 ^s .98	+ 220 ["] .8
	3	+ 14 ^s .44	+ 18 ["] .1	+ 27 ^s .61	+ 221 ["] .9
	4	+ 12 ^s .70	+ 48 ["] .4	+ 25 ^s .08	+ 221 ["] .6
	5	+ 9 ^s .02	+ 71 ["] .2	+ 22 ^s .41	+ 220 ["] .1
	6	+ 3 ^s .92	+ 82 ["] .7	+ 19 ^s .62	+ 217 ["] .2
	7	- 1 ^s .80	+ 80 ["] .6	+ 16 ^s .73	+ 213 ["] .0
	8	- 7 ^s .21	+ 65 ["] .1	+ 13 ^s .74	+ 207 ["] .6
	9	- 11 ^s .39	+ 38 ["] .8	+ 10 ^s .66	+ 200 ["] .8
	10	- 13 ^s .66	+ 6 ["] .1	+ 7 ^s .51	+ 192 ["] .9
	11	- 13 ^s .70	- 27 ["] .5	+ 4 ^s .34	+ 183 ["] .8
	12	- 11 ^s .58	- 56 ["] .7	+ 1 ^s .16	+ 173 ["] .6
	13	- 7 ^s .68	- 77 ["] .1	- 2 ^s .01	+ 162 ["] .4
	14	- 2 ^s .65	- 86 ["] .1	- 5 ^s .16	+ 150 ["] .1
	15	+ 2 ^s .75	- 82 ["] .6	- 8 ^s .27	+ 137 ["] .0
	16	+ 7 ^s .74	- 67 ["] .4	- 11 ^s .32	+ 123 ["] .0
	17	+ 11 ^s .62	- 42 ["] .8	- 14 ^s .28	+ 108 ["] .3
	18	+ 13 ^s .84	- 12 ["] .1	- 17 ^s .14	+ 93 ["] .0
	19	+ 14 ^s .05	+ 20 ["] .2	- 19 ^s .88	+ 77 ["] .1
	20	+ 12 ^s .18	+ 49 ["] .3	- 22 ^s .48	+ 60 ["] .7
	21	+ 8 ^s .44	+ 70 ["] .8	- 24 ^s .92	+ 44 ["] .0
	22	+ 3 ^s .39	+ 81 ["] .0	- 27 ^s .19	+ 27 ["] .1
	23	- 2 ^s .20	+ 77 ["] .9	- 29 ^s .27	+ 10 ["] .0
	24	- 7 ^s .40	+ 62 ["] .0	- 31 ^s .15	- 7 ["] .1
	25	- 11 ^s .34	+ 35 ["] .7	- 32 ^s .82	- 24 ["] .0
	26	- 13 ^s .40	+ 3 ["] .6	- 34 ^s .25	- 40 ["] .8
	27	- 13 ^s .27	- 29 ["] .9	- 35 ^s .46	- 57 ["] .2
	28	- 11 ^s .05	- 56 ["] .9	- 36 ^s .41	- 73 ["] .1
	29	- 7 ^s .15	- 76 ["] .1	- 37 ^s .11	- 88 ["] .5
	30	- 2 ^s .21	- 84 ["] .0	- 37 ^s .57	- 103 ["] .3
	31	+ 3 ^s .03	- 79 ["] .8	- 37 ^s .76	- 117 ["] .3
Feb.	1	+ 7 ^s .83	- 64 ["] .4	- 37 ^s .70	- 130 ["] .5
	2	+ 11 ^s .51	- 39 ["] .9	- 37 ^s .37	- 142 ["] .7
	3	+ 13 ^s .51	- 9 ["] .8	- 36 ^s .79	- 153 ["] .9
	4	+ 13 ^s .62	+ 21 ["] .5	- 35 ^s .96	- 164 ["] .0
	5	+ 11 ^s .67	+ 49 ["] .5	- 34 ^s .89	- 172 ["] .9
	6	+ 7 ^s .95	+ 69 ["] .9	- 33 ^s .59	- 180 ["] .6

		<i>Titan.</i>		<i>Iapetus.</i>	
Greenwich, Noon.		$\alpha_c - A$	$\delta_c - D$	$\alpha_s - A$	$\delta_s - D$
1884, Feb. 7		^s + 2 ⁹ 8	^{''} + 79 ^{''} 1	^s - 32 ⁰ 06	^{''} - 187 ^{''} 1
	8	- 2 ⁴ 5	+ 75 ⁴	- 30 ⁰ 32	- 192 ²
	9	- 7 ⁴ 5	+ 59 ²	- 28 ⁰ 37	- 196 ¹
	10	- 11 ¹ 19	+ 33 ²	- 26 ⁰ 24	- 198 ⁶
	11	- 13 ⁰ 07	+ 1 ⁸	- 23 ⁰ 95	- 199 ⁷
	12	- 12 ⁸ 3	- 29 ⁸	- 21 ⁰ 50	- 199 ⁵
	13	- 10 ⁵ 8	- 56 ⁷	- 18 ⁰ 92	- 198 ⁰
	14	- 6 ⁷ 3	- 74 ⁹	- 16 ⁰ 22	- 195 ²
	15	- 1 ⁹ 5	- 82 ⁰	- 13 ⁰ 42	- 191 ¹
	16	+ 3 ¹ 8	- 77 ³	- 10 ⁰ 55	- 185 ⁷
	17	+ 7 ⁸ 0	- 61 ⁸	- 7 ⁰ 62	- 179 ²
	18	+ 11 ³ 1	- 37 ⁷	- 4 ⁰ 66	- 171 ⁵
	19	+ 13 ² 1	- 8 ³	- 1 ⁰ 67	- 162 ⁸
	20	+ 13 ¹ 9	+ 22 ²	+ 1 ⁰ 31	- 153 ¹
	21	+ 11 ² 22	+ 49 ³	+ 4 ⁰ 27	- 142 ⁴
	22	+ 7 ⁵ 5	+ 68 ⁷	+ 7 ⁰ 19	- 130 ⁸
	23	+ 2 ⁷ 0	+ 77 ²	+ 10 ⁰ 06	- 118 ⁵
	24	- 2 ⁶ 9	+ 73 ¹	+ 12 ⁰ 85	- 105 ⁵
	25	- 7 ³ 9	+ 56 ⁹	+ 15 ⁰ 56	- 92 ⁰
	26	- 10 ⁰ 97	+ 31 ³	+ 18 ⁰ 16	- 77 ⁹
	27	- 12 ⁷ 3	+ 0 ⁶	+ 20 ⁰ 63	- 63 ⁴
	28	- 12 ⁴ 4	- 30 ¹	+ 22 ⁰ 97	- 48 ⁶
	29	- 10 ² 0	- 56 ⁰	+ 25 ⁰ 17	- 33 ⁶
Mar.	1	- 6 ⁴ 3	- 73 ⁵	+ 27 ⁰ 21	- 18 ⁴
	2	- 1 ⁷ 3	- 80 ¹	+ 29 ⁰ 09	- 3 ²
	3	+ 3 ² 1	- 75 ³	+ 30 ⁰ 79	+ 12 ⁰
	4	+ 7 ⁶ 8	- 59 ⁹	+ 32 ⁰ 30	+ 27 ¹
	5	+ 11 ⁰ 5	- 36 ¹	+ 33 ⁰ 62	+ 41 ⁹
	6	+ 12 ⁸ 6	- 7 ³	+ 34 ⁰ 74	+ 56 ⁴
	7	+ 12 ⁸ 0	+ 21 ⁹	+ 35 ⁰ 66	+ 70 ⁶
	8	+ 10 ⁸ 6	+ 48 ⁷	+ 36 ⁰ 38	+ 84 ³
	9	+ 7 ² 6	+ 67 ⁵	+ 36 ⁰ 89	+ 97 ⁴
	10	+ 2 ⁵ 3	+ 75 ⁵	+ 37 ⁰ 19	+ 110 ⁰
	11	- 2 ⁵ 9	+ 71 ³	+ 37 ⁰ 28	+ 121 ⁹
	12	- 7 ² 6	+ 55 ²	+ 37 ⁰ 17	+ 133 ¹
	13	- 10 ⁷ 2	+ 30 ¹	+ 36 ⁰ 84	+ 143 ⁴
	14	- 12 ⁴ 1	0 ⁰	+ 36 ⁰ 32	+ 153 ⁰
	15	- 12 ¹ 0	- 30 ⁰	+ 35 ⁰ 60	+ 161 ⁶
	16	- 9 ⁹ 1	- 55 ³	+ 34 ⁰ 68	+ 169 ⁴

	Titan.		Iapetus.	
Greenwich, Noon.	$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
1884, Mar. 17	- 6 ^s 23	- 72 ["] 2	+ 33 ^s 57	+ 176 ["] 2
18	- 1 ^s 66	- 78 ["] 5	+ 32 ^s 28	+ 182 ["] 0
19	+ 3 ^s 14	- 73 ["] 7	+ 30 ^s 82	+ 186 ["] 7
20	+ 7 ^s 49	- 58 ["] 5	+ 29 ^s 19	+ 190 ["] 4
21	+ 10 ^s 77	- 35 ["] 2	+ 27 ^s 40	+ 193 ["] 0
22	+ 12 ^s 53	- 6 ["] 9	+ 25 ^s 47	+ 194 ["] 6
23	+ 12 ^s 48	+ 22 ["] 2	+ 23 ^s 42	+ 195 ["] 1
24	+ 10 ^s 59	+ 48 ["] 0	+ 21 ^s 26	+ 194 ["] 4

Ephemeris of the Satellite of Neptune, 1883-84. By A. Marth.

P, angle of position of the minor axis of the satellite's apparent orbit, in the direction of superior conjunction.

a, b, major and minor semi-axis of the apparent orbit.

u-U, longitude of the satellite in its orbit reckoned from the point which is in superior conjunction with the planet, or in opposition to the Earth.

U+180°, planetocentric longitude of the Earth, reckoned in the satellite's orbit from the ascending node on the celestial equator.

B, planetocentric latitude of the Earth above the plane of the orbit.

Gr. 1883.	P	a	b	u-U	Diff.	U	B
Sept. 6	318 ^o 83	16 ["] 63	7 ["] 31	181 ^o 56	612 ^o 51	137 ^o 95	26 ^o 08
16	318 ^o 76	16 ["] 72	7 ["] 34	74 ^o 07	47	138 ^o 05	26 ^o 05
26	318 ^o 66	16 ["] 80	7 ["] 36	326 ^o 54	42	138 ^o 20	25 ^o 99
Oct. 6	318 ^o 52	16 ["] 86	7 ["] 37	218 ^o 96	37	138 ^o 39	25 ^o 91
16	318 ^o 36	16 ["] 91	7 ["] 37	111 ^o 33	33	138 ^o 62	25 ^o 82
26	318 ^o 18	16 ["] 95	7 ["] 35	3 ^o 66	31	138 ^o 87	25 ^o 71
Nov. 5	317 ^o 98	16 ["] 97	7 ["] 33	255 ^o 97	29	139 ^o 14	25 ^o 59
15	317 ^o 78	16 ["] 97	7 ["] 30	148 ^o 26	29	139 ^o 42	25 ^o 46
25	317 ^o 59	16 ["] 96	7 ["] 26	40 ^o 55	29	139 ^o 70	25 ^o 33
Dec. 5	317 ^o 41	16 ["] 92	7 ["] 21	292 ^o 84	30	139 ^o 96	25 ^o 21
15	317 ^o 25	16 ["] 87	7 ["] 16	185 ^o 14	34	140 ^o 19	25 ^o 10
25	317 ^o 11	16 ["] 81	7 ["] 10	77 ^o 48	37	140 ^o 38	25 ^o 00
1884. Jan. 4	317 ^o 00	16 ["] 73	7 ["] 05	329 ^o 85	41	140 ^o 53	24 ^o 92
14	316 ^o 93	16 ["] 65	7 ["] 00	222 ^o 26	46	140 ^o 63	24 ^o 86
24	316 ^o 89	16 ["] 56	6 ["] 95	114 ^o 72	52	140 ^o 68	24 ^o 83
Feb. 3	316 ^o 90	16 ["] 46	6 ["] 91	7 ^o 24	57	140 ^o 67	24 ^o 82
13	316 ^o 94	16 ["] 37	6 ["] 88	259 ^o 81	63	140 ^o 61	24 ^o 84
23	317 ^o 02	16 ["] 27	6 ["] 85	152 ^o 44	612 ^o 69	140 ^o 49	24 ^o 88
Mar. 4	317 ^o 14	16 ["] 19	6 ["] 83	45 ^o 13		140 ^o 31	24 ^o 95

If the values of P , a , b and $u-U$ are interpolated for the times for which the apparent places of the satellite are required, the position-angles p and distances s are found by

$$s \sin (P-p) = a \sin (u-U).$$

$$s \cos (P-p) = b \cos (u-U).$$

The satellite moves in the direction of *decreasing* position-angles, and will be at its greatest elongations and at its *superior* and *inferior* conjunctions with the planet at the following hours, Greenwich M.T.:—

<i>nf. elong.</i> $p = P + 90^\circ$ $s = a$		<i>sup. conj.</i> P b		<i>sp. elong.</i> $P - 90^\circ$ a		<i>inf. conj.</i> $P + 180^\circ$ b	
1883.	h		h		h		h
Sept. 7	10.7	Sept. 8	2.9	Sept. 10	9.2	Sept. 11	20.4
	13 7'		14 19.0		16 6.2		17 17.5
	19 4.8		20 16.0		22 3.3		23 14.6
	25 1.8		26 13.1		28 0.4		29 11.7
	30 22.9	Oct. 2	10.2	Oct. 3	21.5	Oct. 5	8.7
Oct. 6	20.0		8 7.3		9 18.6		11 5.8
	12 17.1		14 4.4		15 15.6		17 2.9
	18 14.2		20 1.5		21 12.7		23 0.0
	24 11.3		25 22.6		27 9.8		28 21.1
	30 8.4		31 19.7	Nov. 2	6.9	Nov. 3	18.2
Nov. 5	5.5	Nov. 6	16.8		8 4.0		9 15.3
	11 2.6		12 13.9		14 1.2		15 12.4
	16 23.7		18 11.0		19 22.3		21 9.5
	22 20.8		24 8.1		25 19.4		27 6.7
	28 17.9		30 5.2	Dec. 1	16.5	Dec. 2	3.8
Dec. 4	15.0	Dec. 6	2.3		7 13.6		9 0.9
	10 12.2		11 23.4		13 10.7		14 22.0
	16 9.3		17 20.5		19 7.8		20 19.1
	22 6.4		23 17.6		25 4.9		26 16.2
	28 3.4		29 14.7		31 2.0	Jan. 1	13.3
1884.							
Jan. 3	0.5	Jan. 4	11.8	Jan. 5	23.1		7 10.4
	8 21.6		10 8.9		11 20.2		13 7.4
	14 18.7		16 6.0		17 17.2		19 4.5
	20 15.8		22 3.0		23 14.3		25 1.6
	26 12.8		28 0.1		29 11.4		30 22.6
Feb. 1	9.9	Feb. 2	21.2	Feb. 4	8.4	Feb. 5	19.7
	7 6.9		8 18.2		10 5.5		11 16.7
	13 4.0		14 15.2		16 2.5		17 13.8
	19 1.0		20 12.3		21 23.5		23 10.8
	24 22.0		26 9.3		27 20.6		29 7.8
Mar. 1	19.1	Mar. 3	6.3	Mar. 4	17.6	Mar. 6	4.8